Warm Mix Asphalt Processes Applicable to North Dakota

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NDDOT RAC Meeting

November 9th 2011

Introduction

Warm mix asphalt (WMA) represents technologies that allow production and placement of asphalt mixes at lower temperatures, achieved through foamed asphalt or use of additives.

- Fuel consumption
- Workability and Compaction
- Haul distances
- Paving season

WMA Technologies

- Chemical Processes: CECABASE, Evotherm, Hypertherm, Rediset WMX
- Foaming Processes: Accu Shear, Advera WMA, AQUABlack, Double Barrel Green, Ultrafoam,….
- Organic Additives: Astech PER, Sasobit, SonneWarmix, Thiopave, TLA-X Warm Mix

Outline of Presentation

- Objectives of study
- Scope of work
- Literature study
- Survey
- Analysis of responses
- Recommendations

Objectives of this Study

- Evaluate the applicability of WMA processes and additives to North Dakota projects, as used in target states.
- Techniques, equipment, and additives that are most suitable for the use of WMA in North Dakota.
- Specification changes to account for differences in production and/or placement of WMA, as compared to HMA.

Geographic Scope of Research

Scope of Work

- Literature Review:
  - Journal and conference papers
  - Publications by state DOTs (TRB database)
  - Websites of target states
  - Documents collected through follow ups
- Data Collection:
  - Survey, 49 contacts in 27 states. Selected industry contacts
  - Phone Calls
  - Email Follow ups
- Data Analysis
- Final Report

Literature - Technologies

- Comprehensive section on WMA technologies
- Main WMA technologies currently available for each type (foaming, chemical, organic) are discussed.
- For each processes:
  - Contact details of manufacturer
  - Dosage (if applicable)
  - Reduction in temperature (mixing/compaction)
  - Modifications to mix design/plant

Literature - NCHRP 09-43

- Volumetric Properties
- Binder Grade Selection
- RAP in WMA
- Short-Term Oven Conditioning
- Coating, Workability, and Compactability
- Moisture Sensitivity
- Rutting Resistance
- Performance Evaluation

Literature - WMA Study at NDSU

- WMA performance is as well as HMA to this point
- Foaming: lowest additional cost for large-scale production.
- Chemical additives: the lowest additional cost on a small-scale production.
- The contractors' main concern about WMA is cost.
- Foaming appears to be best suited for use in North Dakota.

Literature - Specs, Special Provisions, …

Through

- web-search (TRB database and DOTs web pages)
- Survey
- Phone and email follow ups

the following were collected:

- Specifications
- Special provisions
- List of approved processes
- Approval process for new technologies
- Publications of field trials and experiments on WMA

Appendix C consists of all gathered documents

Literature - Samples of States' Specifications

- Colorado: Plant temperatures more than 100°F below existing HMA mixing temperatures are not allowed for WMA.
- Idaho: two additional tests for WMA
  - Immersion compression
  - Rutting susceptibility (APA)
- Illinois: Modifications in
  - Mix Design Verification
  - QC/QA testing
  - Construction Requirements

Samples of State's Specifications (cont'd)

- Iowa:
  - Production temperature should be between 215°F (102°C) and 280°F (138°C) until placed on the grade.
- Michigan:
  - Sampling from a point where the water or water foaming additive is added, and the point where the binder is added to mixture.
- NYDOT: Requires tests results of both the HMA and WMA samples using either of:
  - Asphalt Pavement Analyzer (APA),
  - Hamburg Wheel Track (HWT)
  - Asphalt Mixture Performance Tester (AMPT)

Samples of State's Specifications (cont'd)

- Ohio:
  - Sample the binder before spraying for foaming.
  - Mixing plants should be pre-approved by the agency.
- Oregon:
  - Recycled asphalt shingles cannot be used in WMA mixes with min. compaction temperatures <260°F.
- South Dakota:
  - Modifications in air voids, in-place density, and pay factor.
  - Placement and compaction temperature cannot drop below 140°F (60°C).

Survey - Lay Out

1. General
   - Comparison of HMA and WMA
   - Cost Issues
   - Production Tonnage

2. Technology
   - Agencies' experience with different WMA technologies
   - Observed distresses

Survey - Lay Out (cont'd)

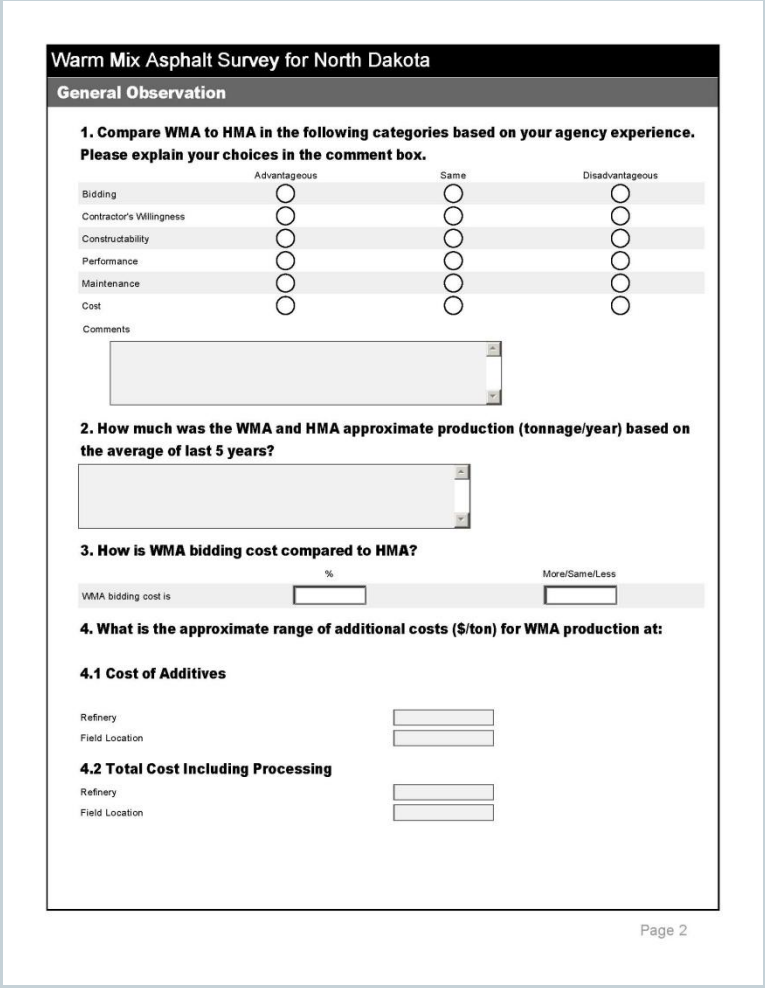
3. Mix Design: Modifications in selection of
   - Materials
   - Binder
   - Design aggregate structure
   - Lab testing
   - Additives
   - RAP and RAS utilization

Survey - Lay Out (cont'd)

4. Specifications: Modifications compared to HMA, new technology approval process

5. Acceptance Plan: modifications in sampling, quality characteristics, spec limits, risk, and pay factor.

Survey - Snapshot



Warm Mix Asphalt Survey for North Dakota

General Observation

1. Compare WMA to HMA in the following categories based on your agency experience. Please explain your choices in the comment box.

	Advantageous	Same	Disadvantageous
Bidding	○	○	○
Contractor's Willingness	○	○	○
Constructability	○	○	○
Performance	○	○	○
Maintenance	○	○	○
Cost	○	○	○

Comments

2. How much was the WMA and HMA approximate production (tonnage/year) based on the average of last 5 years?

3. How is WMA bidding cost compared to HMA?

	%	More/Same/Less
WMA bidding cost is		

4. What is the approximate range of additional costs ($/ton) for WMA production at:

4.1 Cost of Additives

Refinery

Field Location

4.2 Total Cost Including Processing

Refinery

Field Location

Page 2

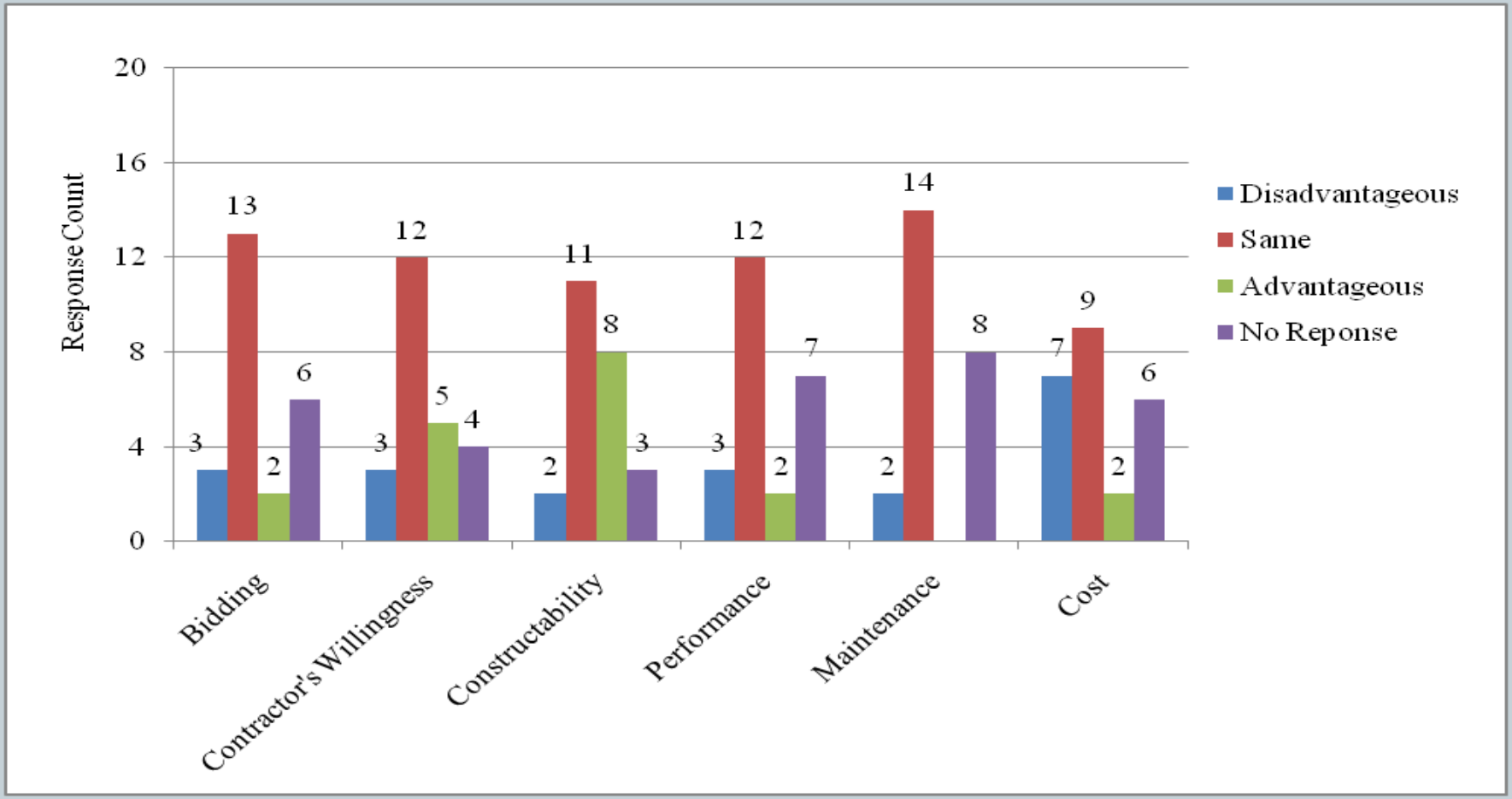
- Survey was sent to 49 people in 27 states.
- Follow ups were done by phone and email
- Some replies indicated more than one answer.

Survey - Agencies' Responses to the Survey Questions (24 questions)

State	1	2	3	4		5	6	7			8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
				4.1	4.2			7.1	7.2	7.3																	
Colorado	P	C	C	N	N	N	C	C	C	C	C	C	C	C	C	C	N	C	C	C	C	C	C	C	C	C	C
Idaho	C	C	C	P	N	C	C	P	C	N	C	C	C	C	C	C	N	C	C	C	N	N	C	C	C	C	C
Indiana	C	C	C	N	C	C	C	P	P	P	C	C	C	C	C	C	C	P	C	C	C	C	C	C	C	C	P
Iowa	C	C	C	C	P	C	C	C	C	C	C	C	N	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Kansas	C	C	C	N	N	C	C	C	C	N	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Maine	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Manitoba, Canada	C	C	N	P	N	C	C	C	C	C	C	C	C	P	C	C	P	C	C	C	P	C	C	C	C	C	P
Michigan	C	C	C	N	C	C	C	N	P	N	C	C	C	P	C	C	C	P	C	C	C	C	C	C	C	C	C
Minnesota	C	C	C	N	C	C	C	C	C	P	P	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Missouri	C	C	C	C	N	C	C	C	C	C	C	C	C	C	C	C	N	P	C	C	C	C	C	C	C	C	P
Montana(1)	C	C	C	N	N	C	C	C	P	P	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Montana(2)	C	N	N	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	C
Nebraska	C	C	C	N	N	C	C	C	C	P	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	N
Nevada(1)	C	C	C	C	C	C	C	N	N	N	C	C	C	C	C	C	C	P	P	C	C	C	C	C	C	C	C
Nevada(2)	P	C	N	N	N	N	C	N	P	P	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
New Hampshire	C	C	N	N	P	C	C	C	C	N	C	C	C	C	P	C	P	C	C	C	C	C	C	C	C	C	P
New York	C	C	C	C	N	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	P
Ohio	C	C	C	N	C	C	C	C	P	C	C	C	C	C	C	C	N	P	C	C	C	C	C	C	C	C	C
Oregon	P	C	N	N	N	N	N	N	N	N	N	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Saskatchewan	P	C	N	N	N	C	C	C	C	N	C	C	C	C	C	C	N	P	C	C	C	C	C	C	C	C	P
South Dakota	C	C	N	N	N	C	C	C	C	C	P	C	N	N	C	P	C	C	C	P	P	C	C	C	C	N	N
Utah	C	C	C	N	P	N	C	C	C	N	C	C	C	C	C	P	C	P	C	C	C	C	C	C	C	C	P
Vermont	C	C	C	C	C	C	C	P	C	N	C	C	C	C	C	C	C	P	C	C	C	C	C	C	C	C	C
Washington	C	C	C	C	C	C	C	N	C	C	C	C	C	C	C	P	P	P	C	C	P	C	C	C	C	C	P

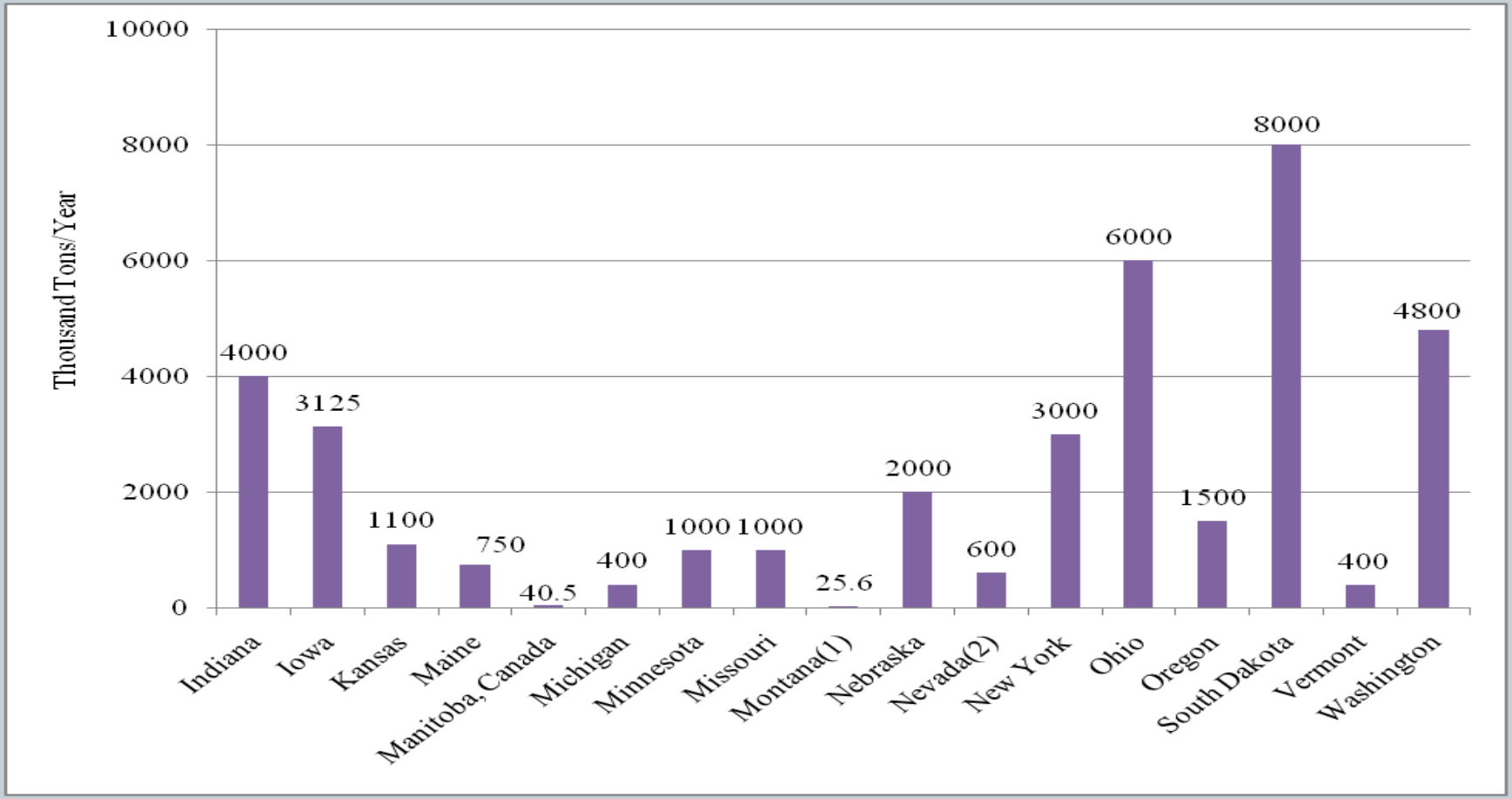
Complete Answer: 79%, Partial Answer: 8%, No Answer: 13%

Analysis of Responses - General



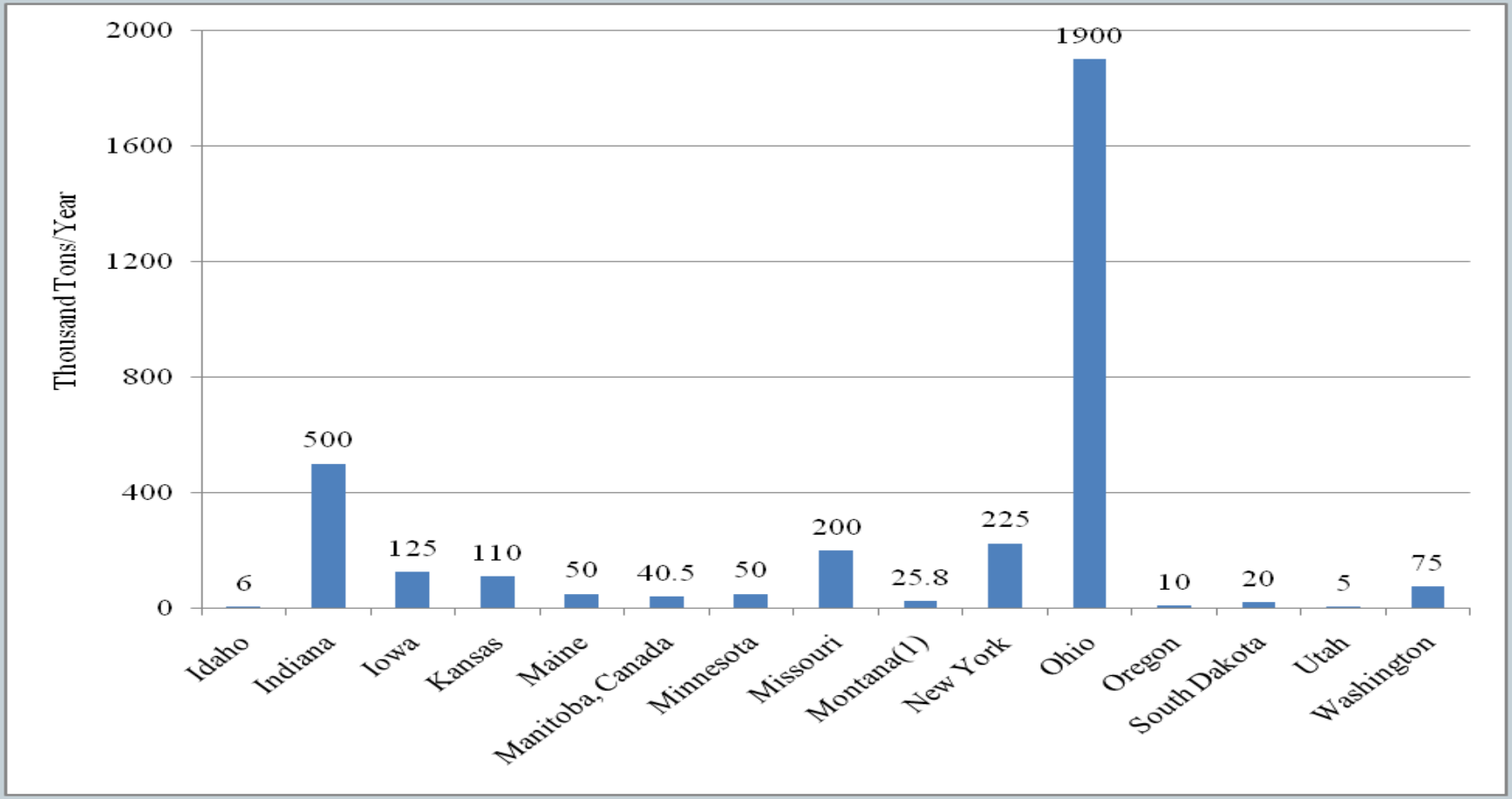
Comparison between WMA and HMA based on agencies' experience

Analysis of Responses - General (cont'd)



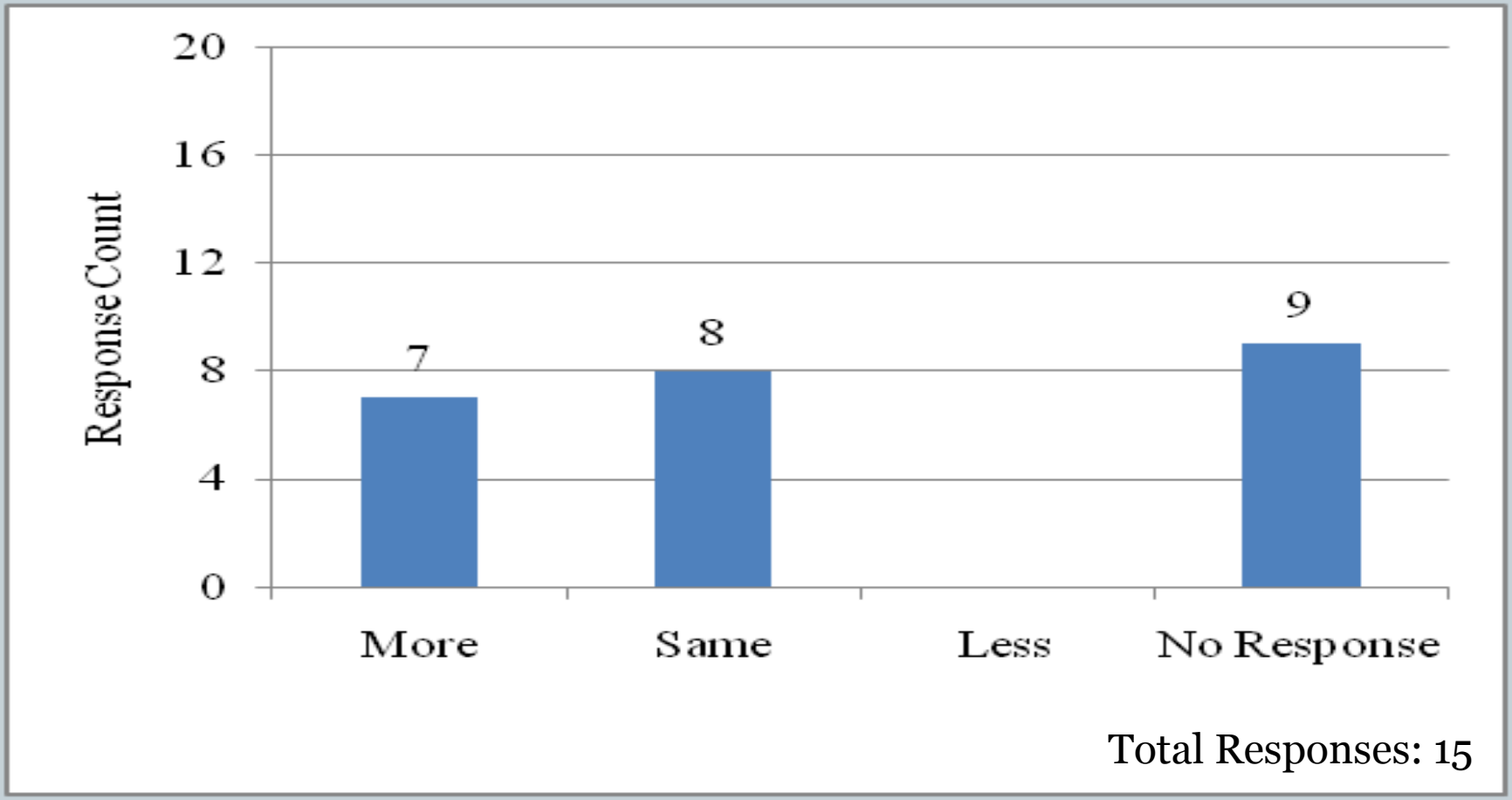
Approximate HMA production (average of last 5 years)

Analysis of Responses - General (cont'd)



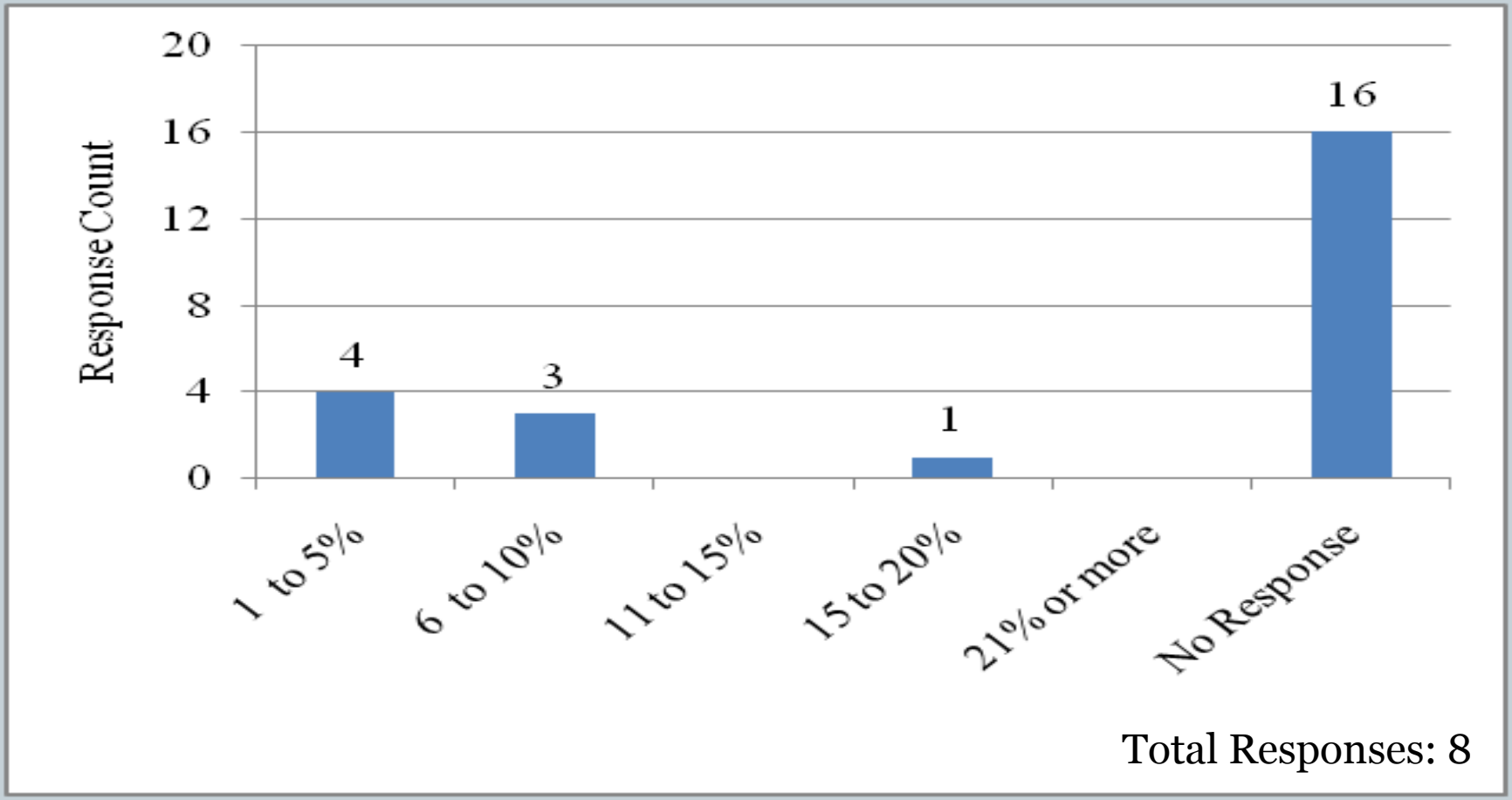
Approximate WMA production (average of last 5 years)

Analysis of Responses - General (cont'd)



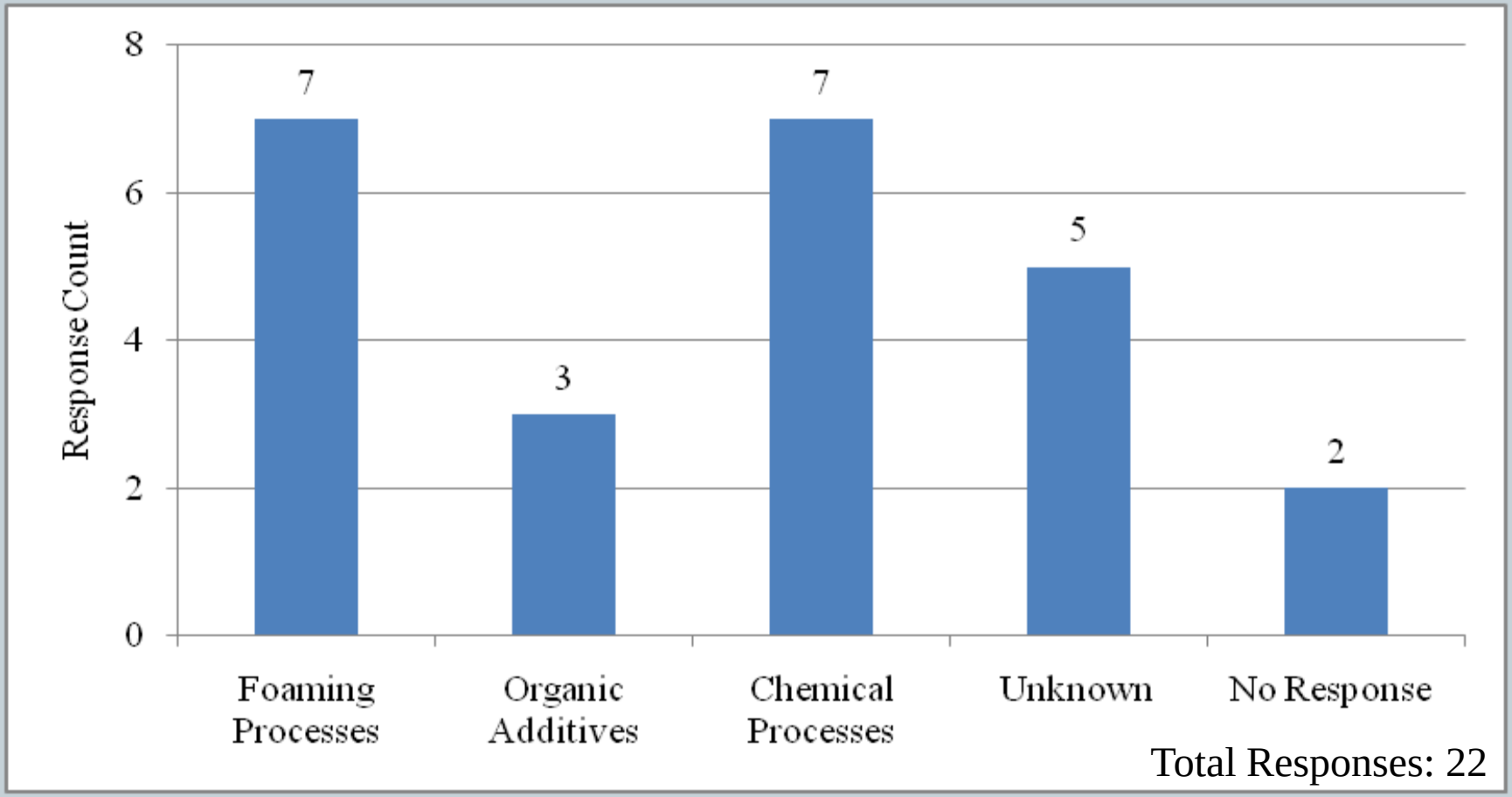
WMA bidding cost compared to HMA

Analysis of Responses - General (cont'd)



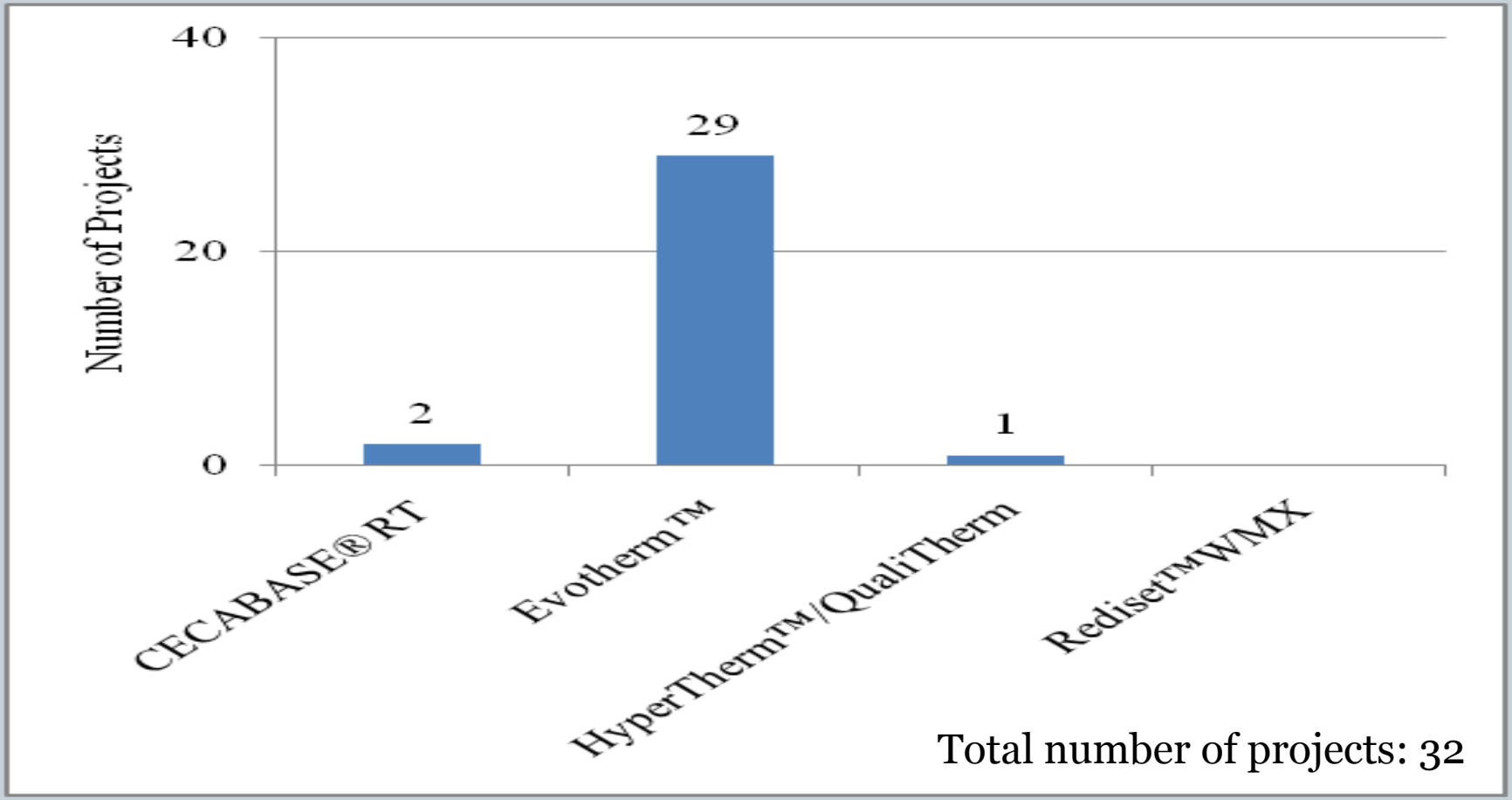
Increase of WMA bidding cost compared to HMA

Analysis of Responses - General (cont'd)



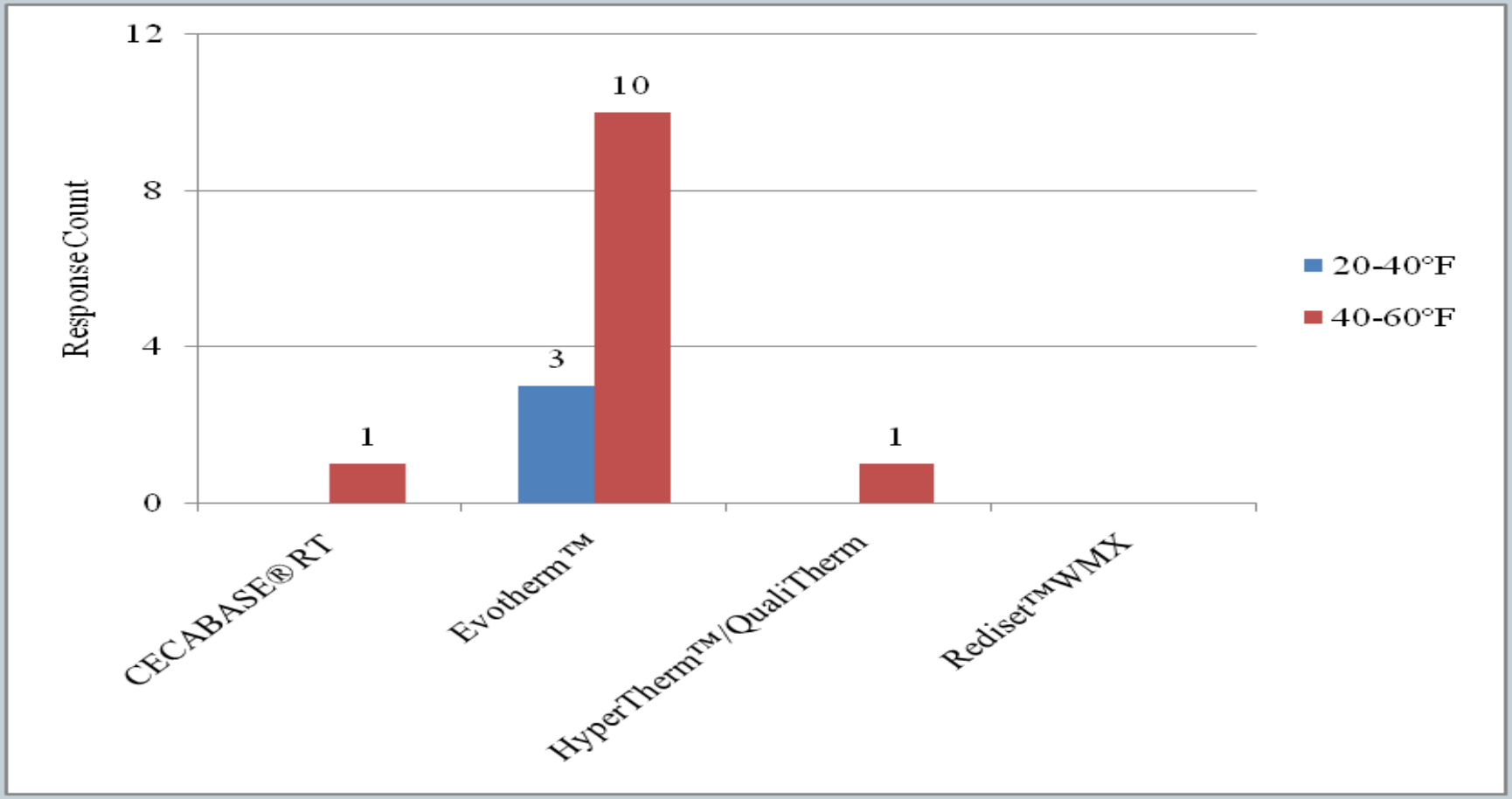
Distribution of WMA type preference

Analysis of Responses - Technology



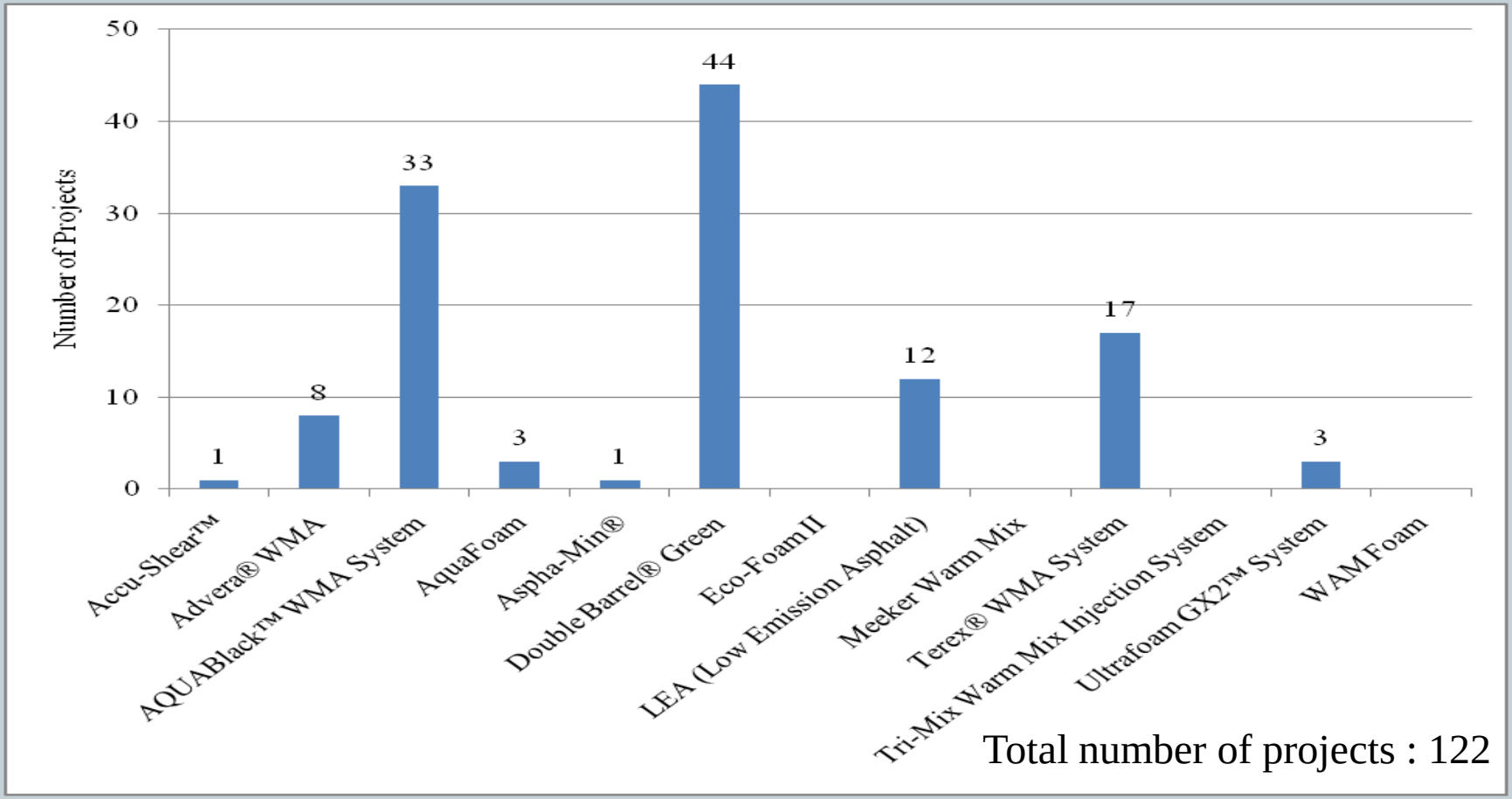
Number of constructed projects for each chemical process

Analysis of Responses - Technology (cont'd)



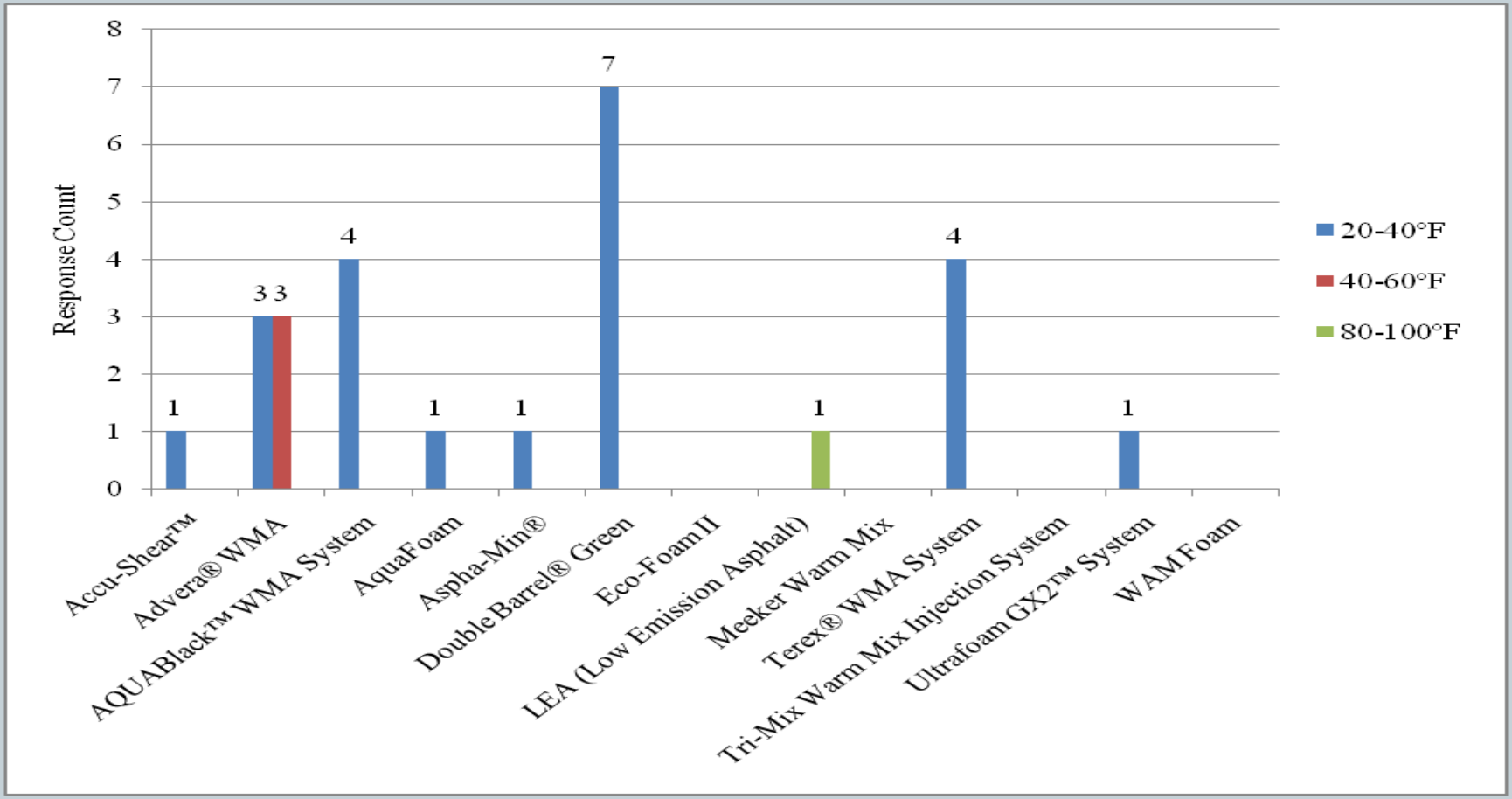
Mixing temperature reduction (°F) achieved for each chemical process

Analysis of Responses - Technology (cont'd)



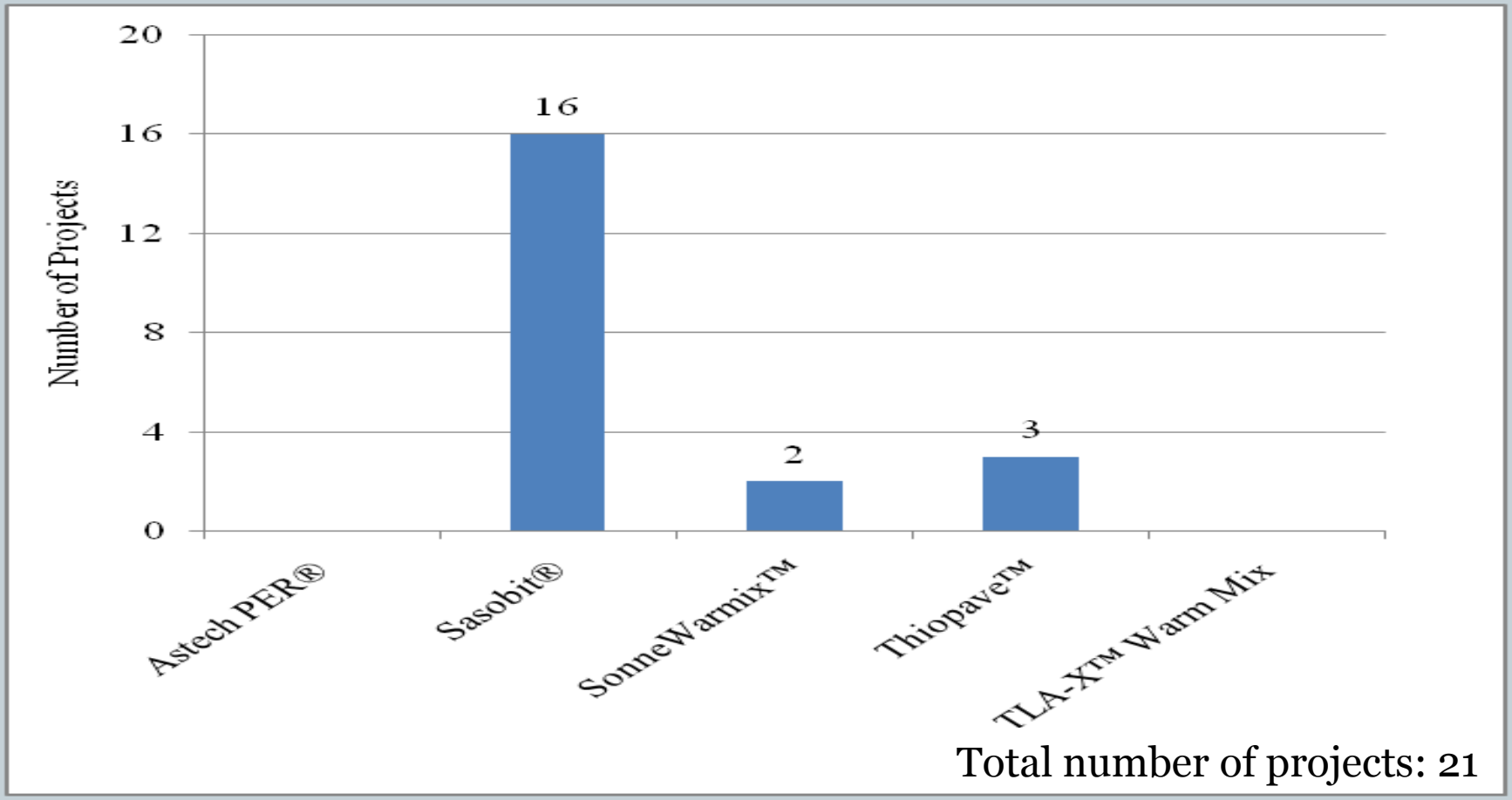
Number of constructed projects for each foaming process

Analysis of Responses - Technology (cont'd)



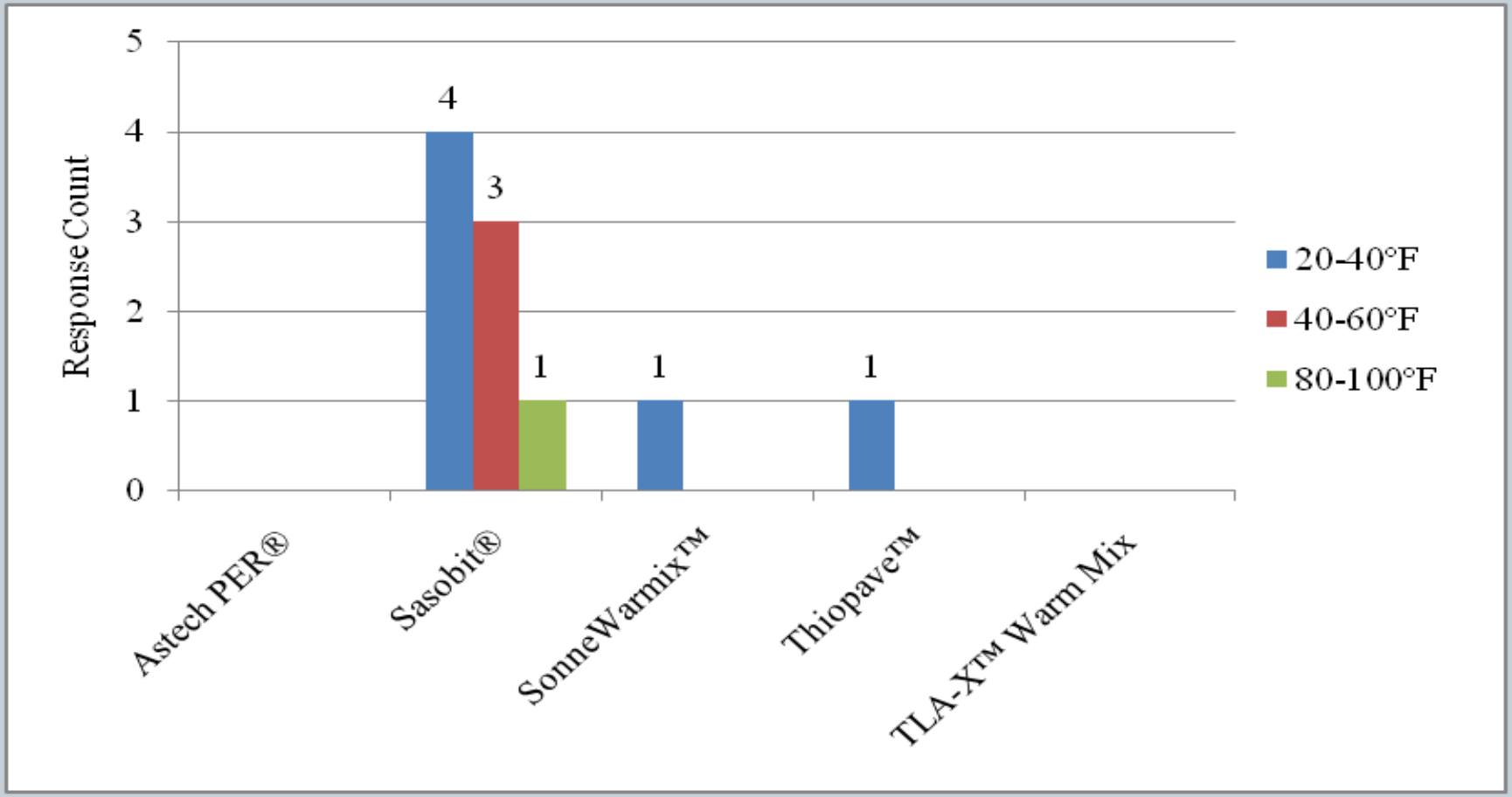
Mixing temperature reduction (°F) achieved for each foaming process

Analysis of Responses - Technology (cont'd)



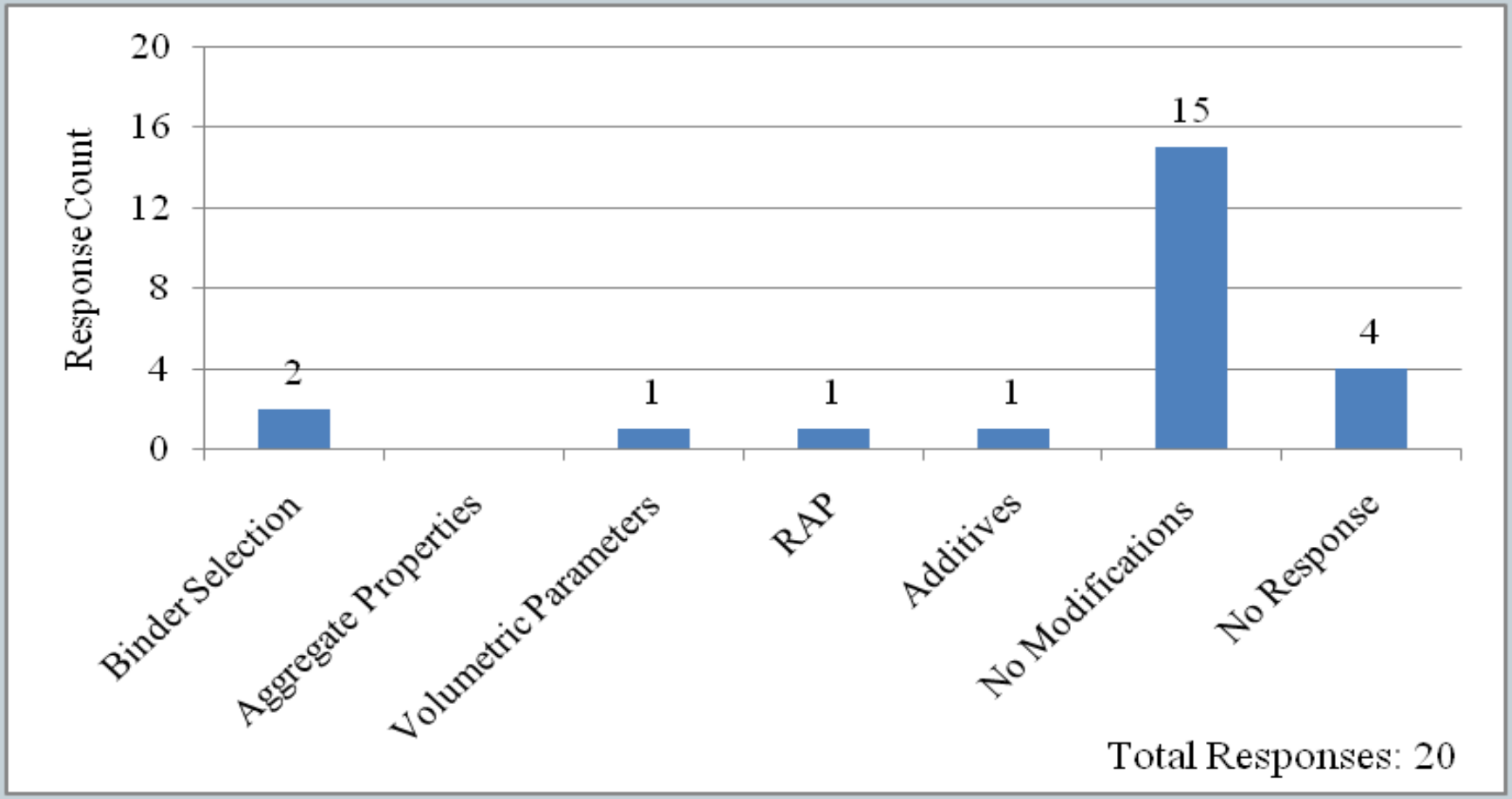
Number of constructed projects for each organic additive

Analysis of Responses - Technology (cont'd)



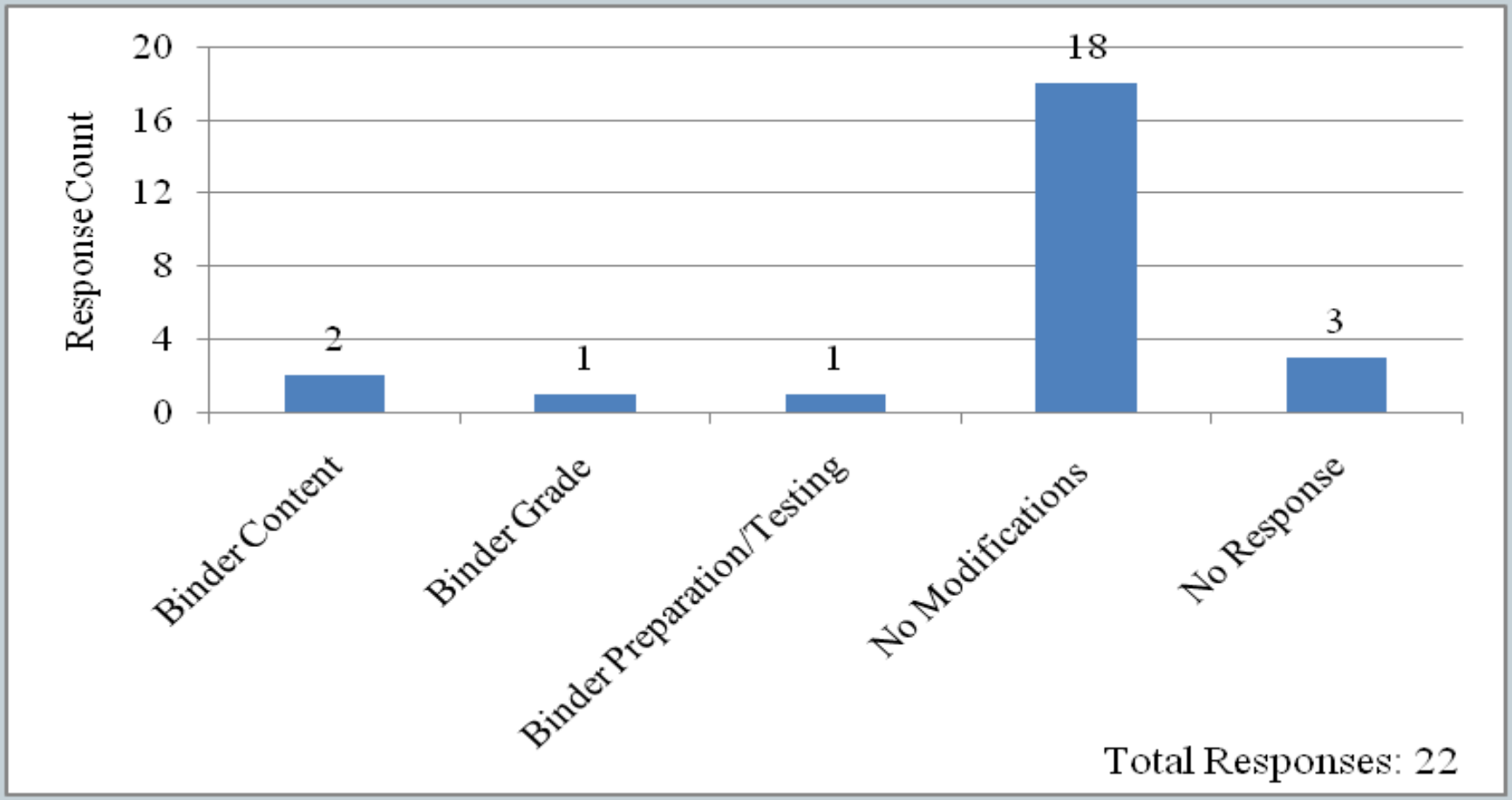
Mixing temperature reduction (°F) achieved for each organic additive

Analysis of Responses - Mix Design



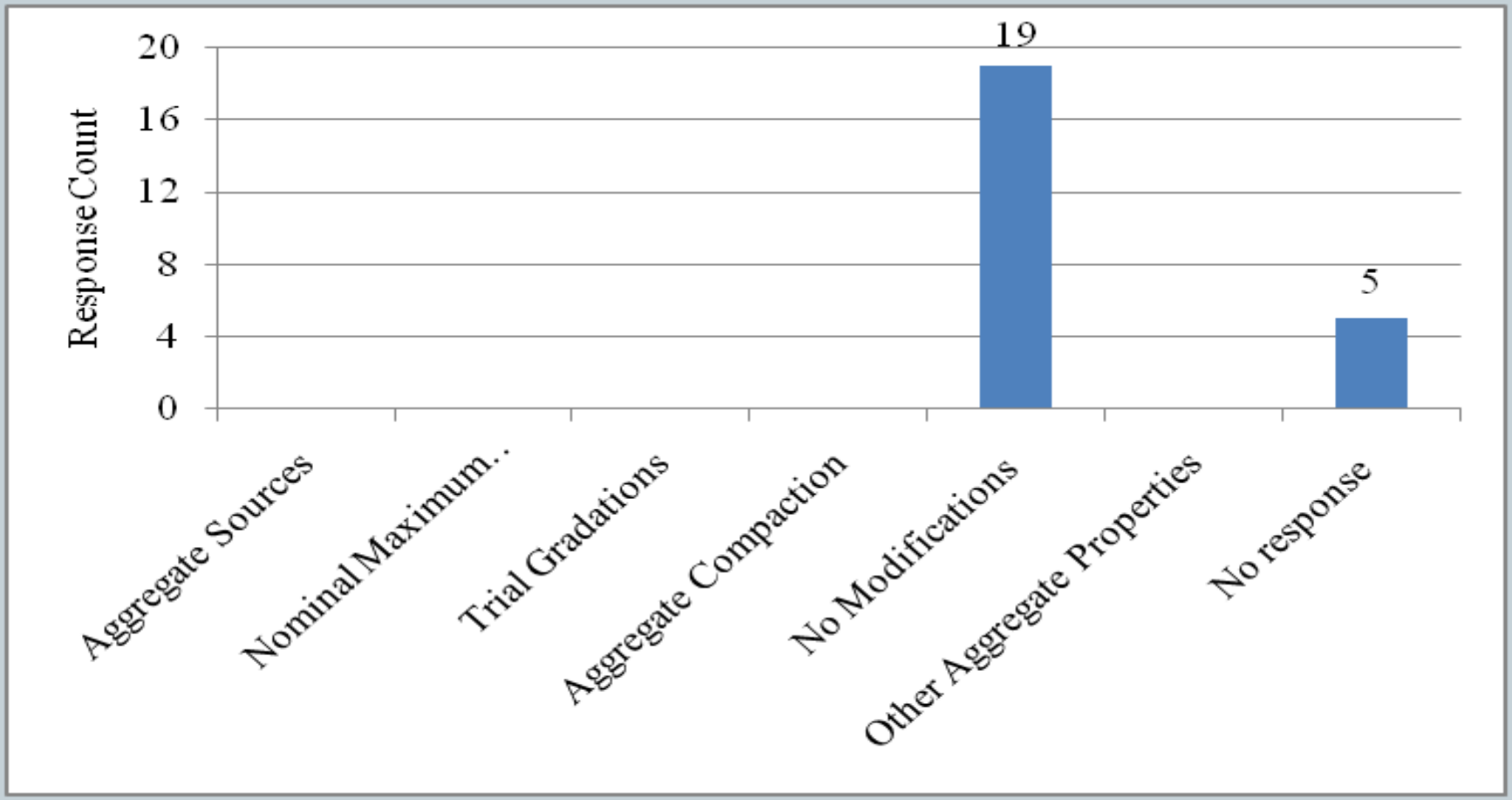
Modifications in WMA material selections items compared to HMA

Analysis of Responses - Mix Design (cont'd)



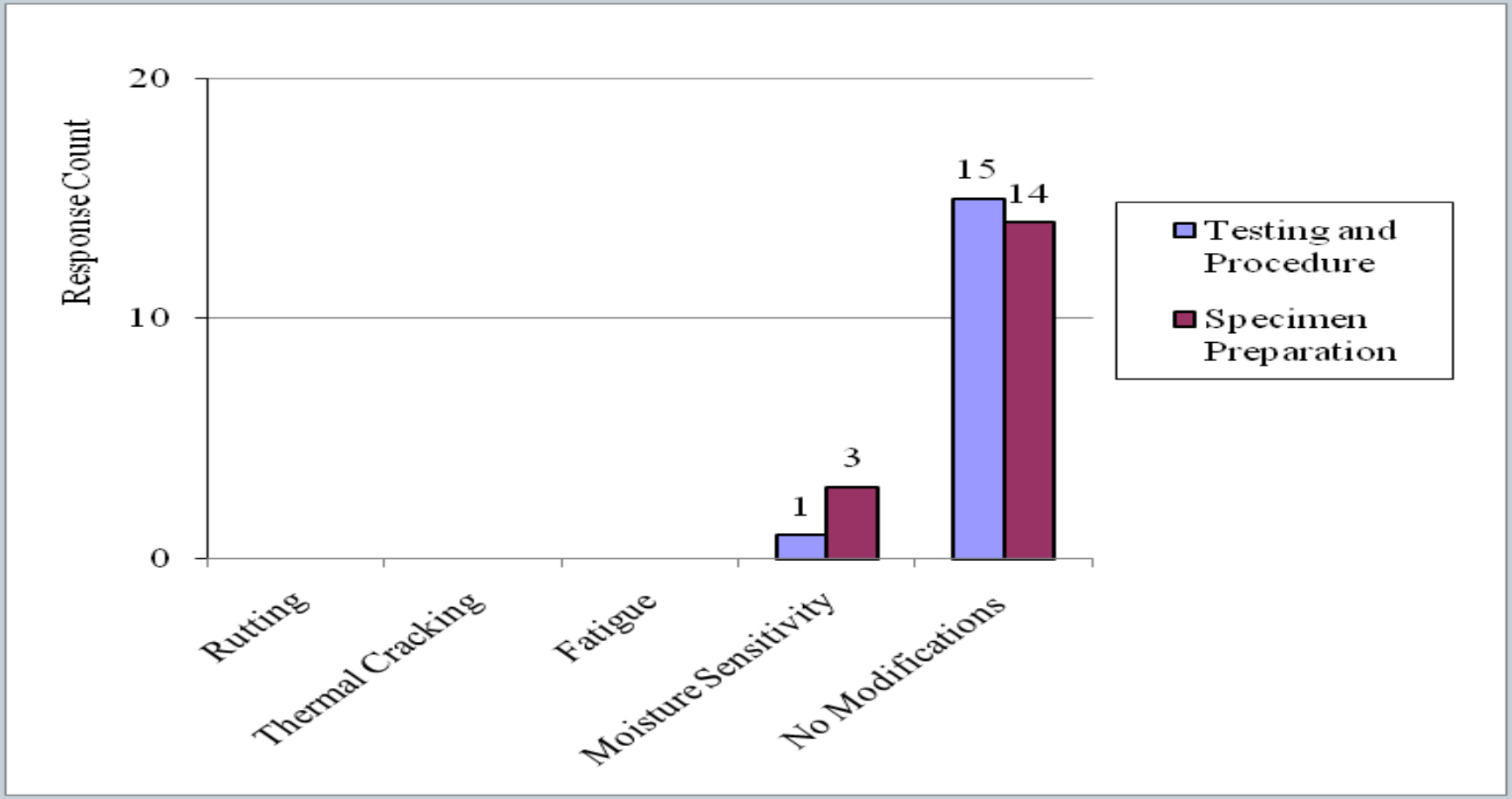
Modifications in WMA binder selection items compared to HMA

Analysis of Responses - Mix Design (cont'd)



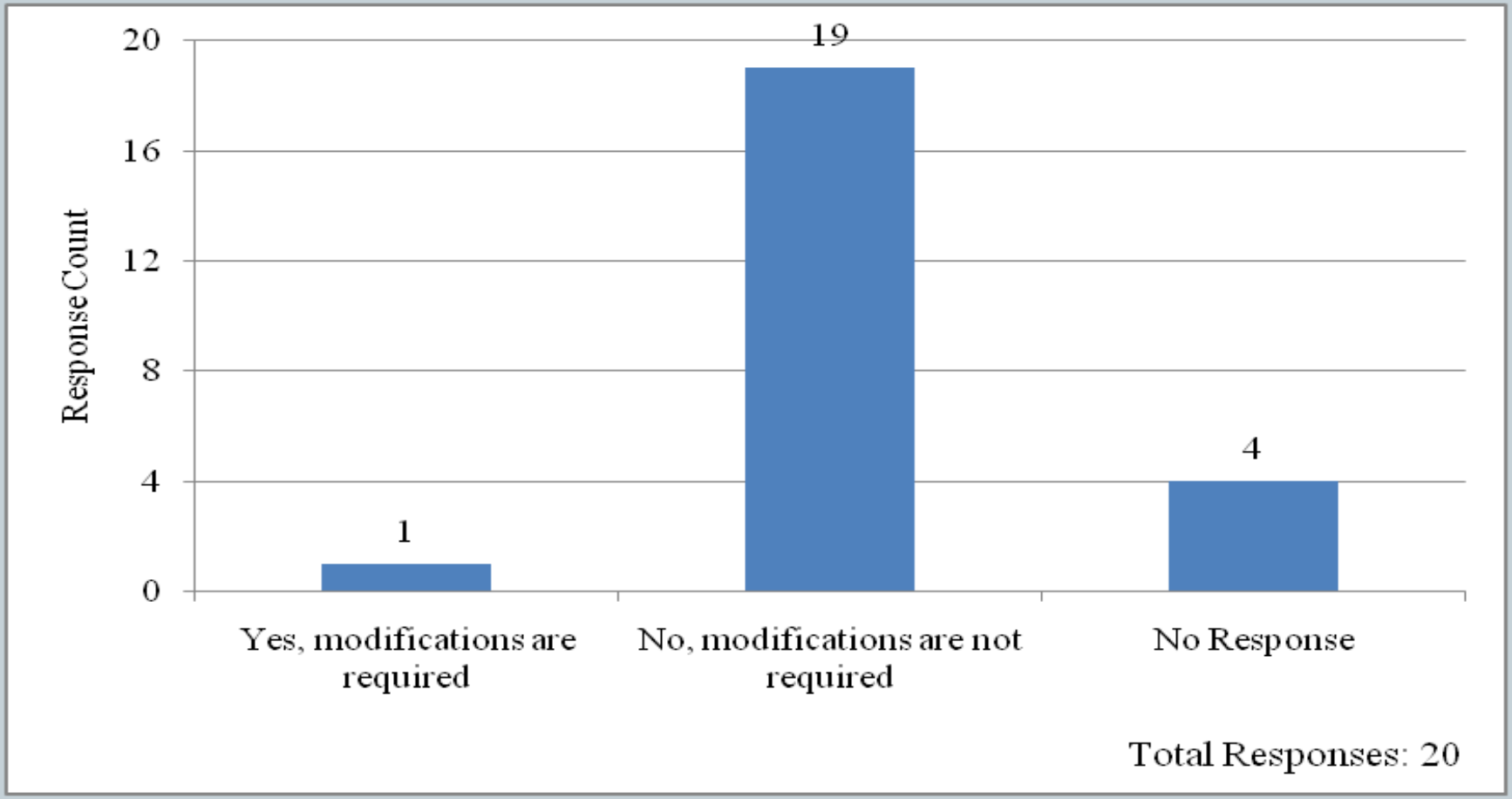
Modifications in WMA design aggregate structure compared to HMA

Analysis of Responses - Mix Design (cont'd)



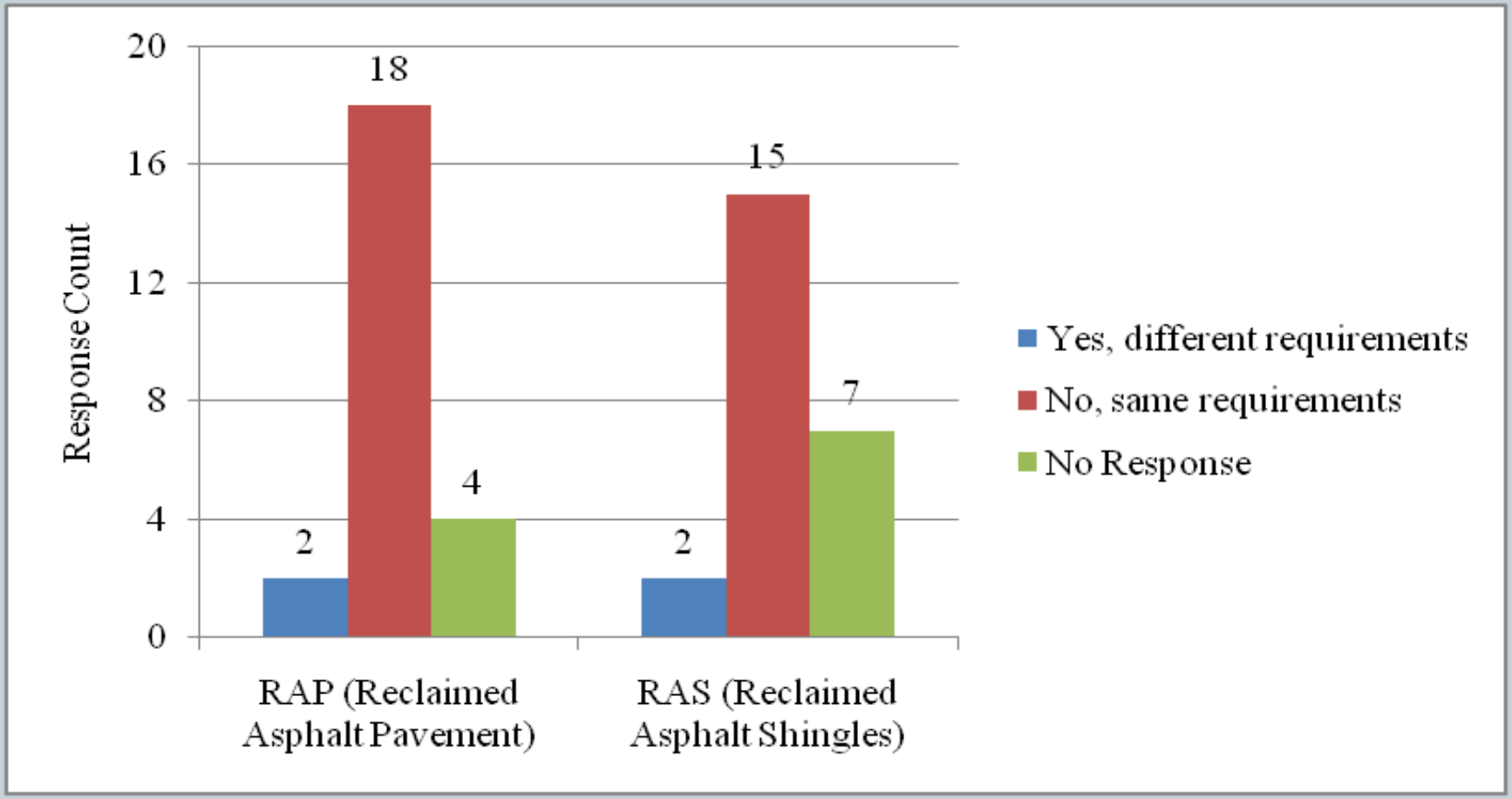
WMA lab performance tests modifications compared to HMA

Analysis of Responses - Mix Design (cont'd)



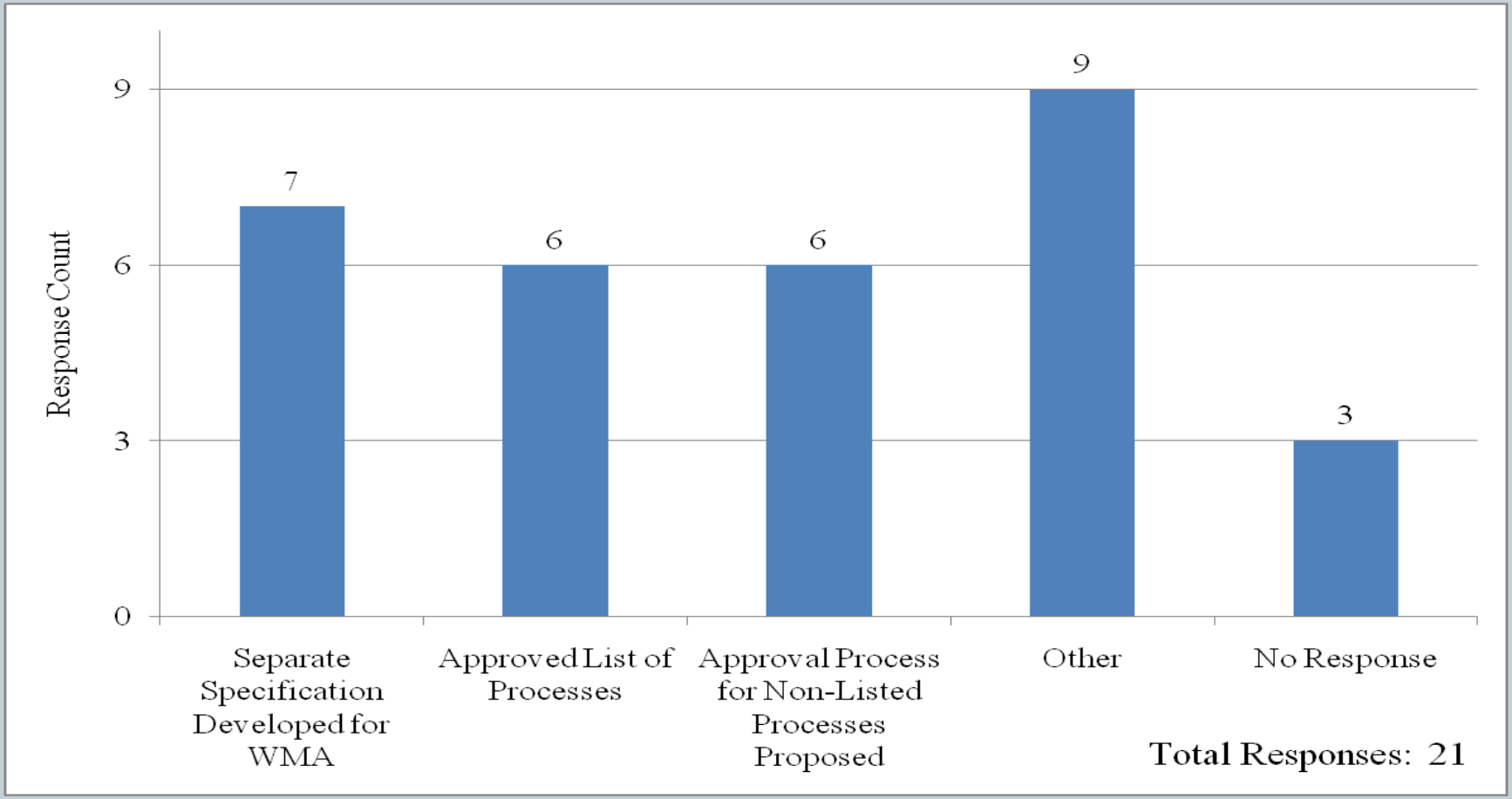
WMA requirements on anti-stripping agent compared to HMA

Analysis of Responses - Mix Design (cont'd)



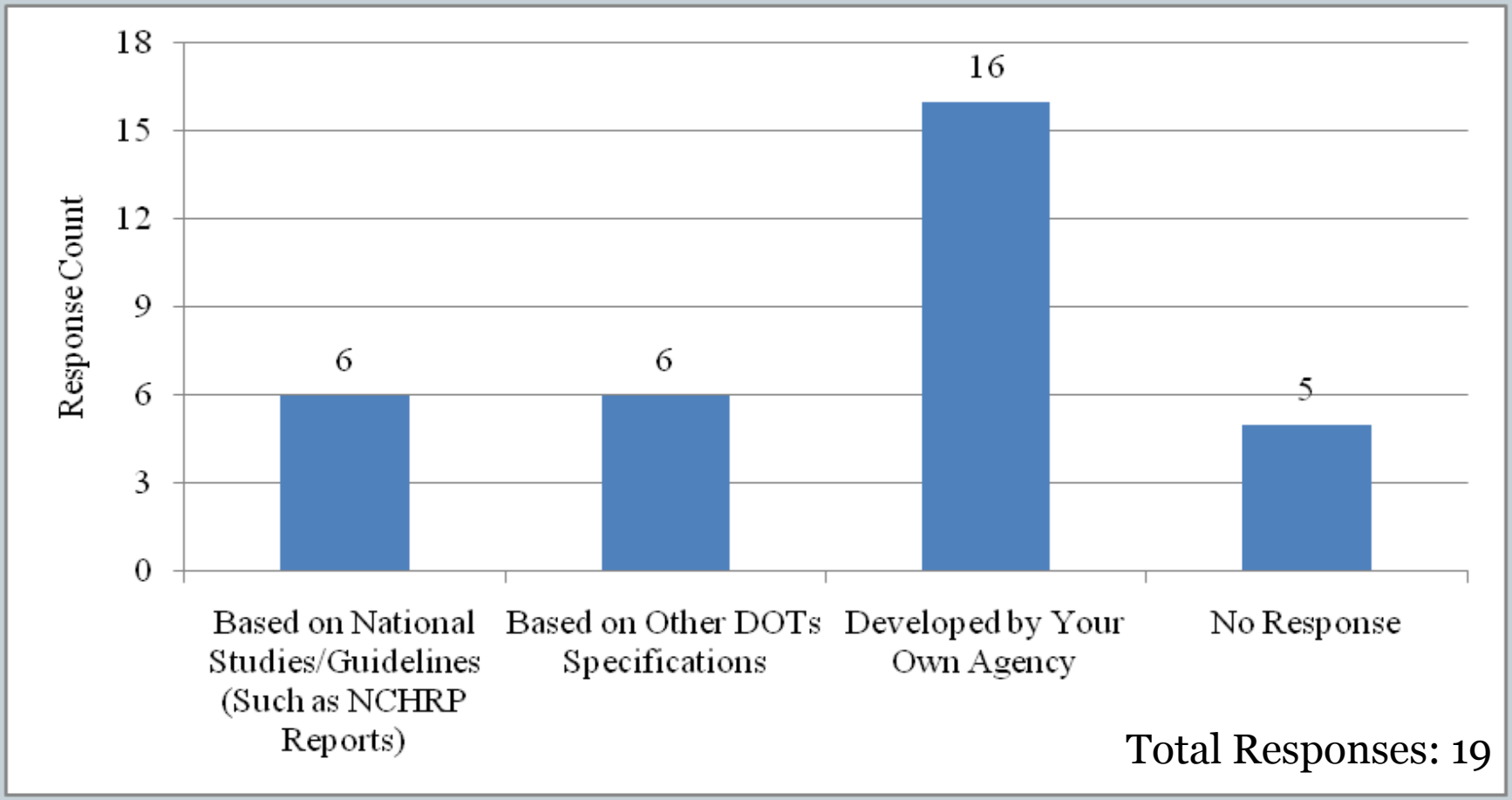
WMA requirements on RAP and RAS compared to HMA

Analysis of Responses - Specifications



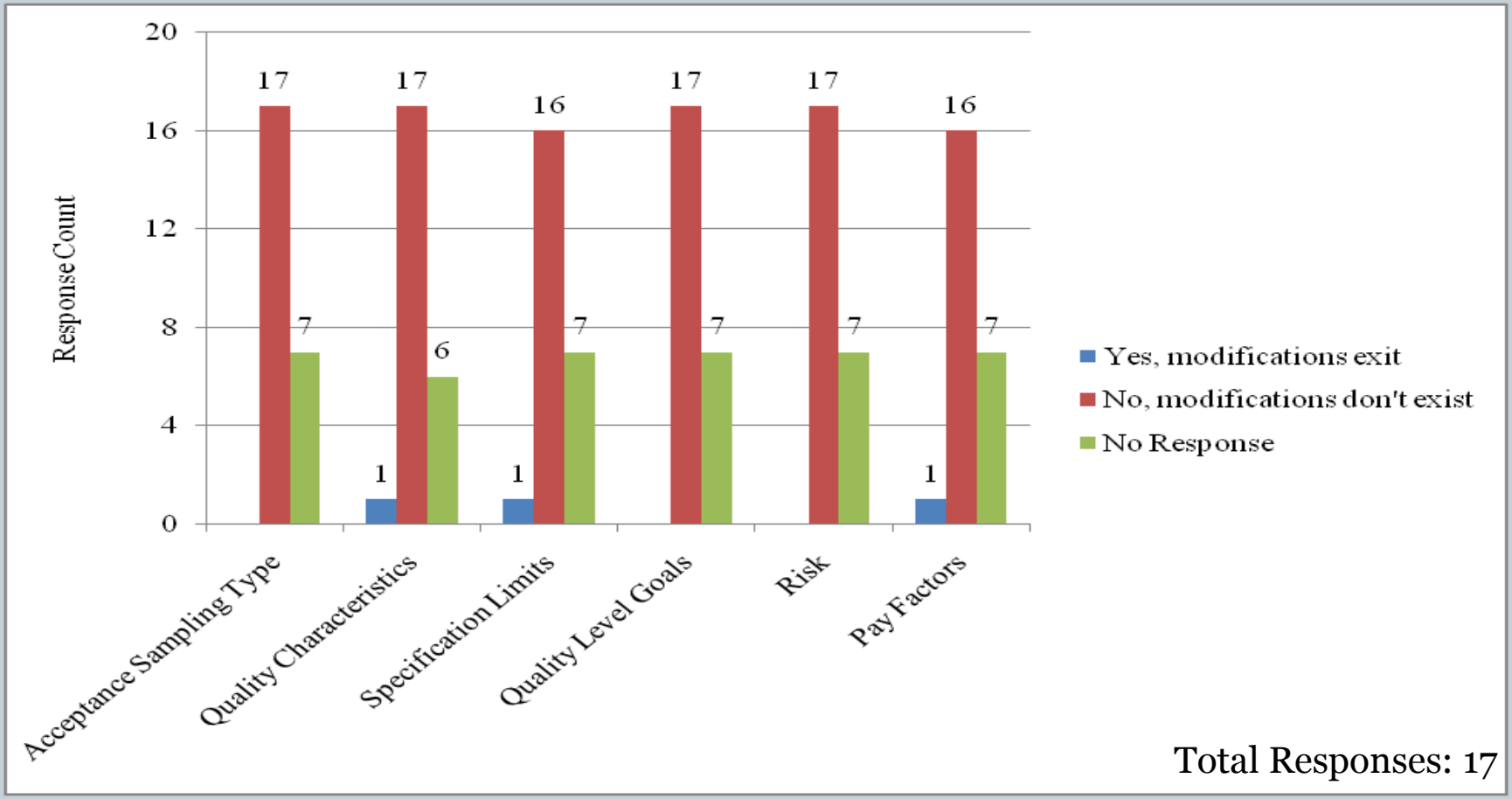
Mechanisms for developing warm mix asphalt in agencies

Analysis of Responses - Specifications (cont'd)



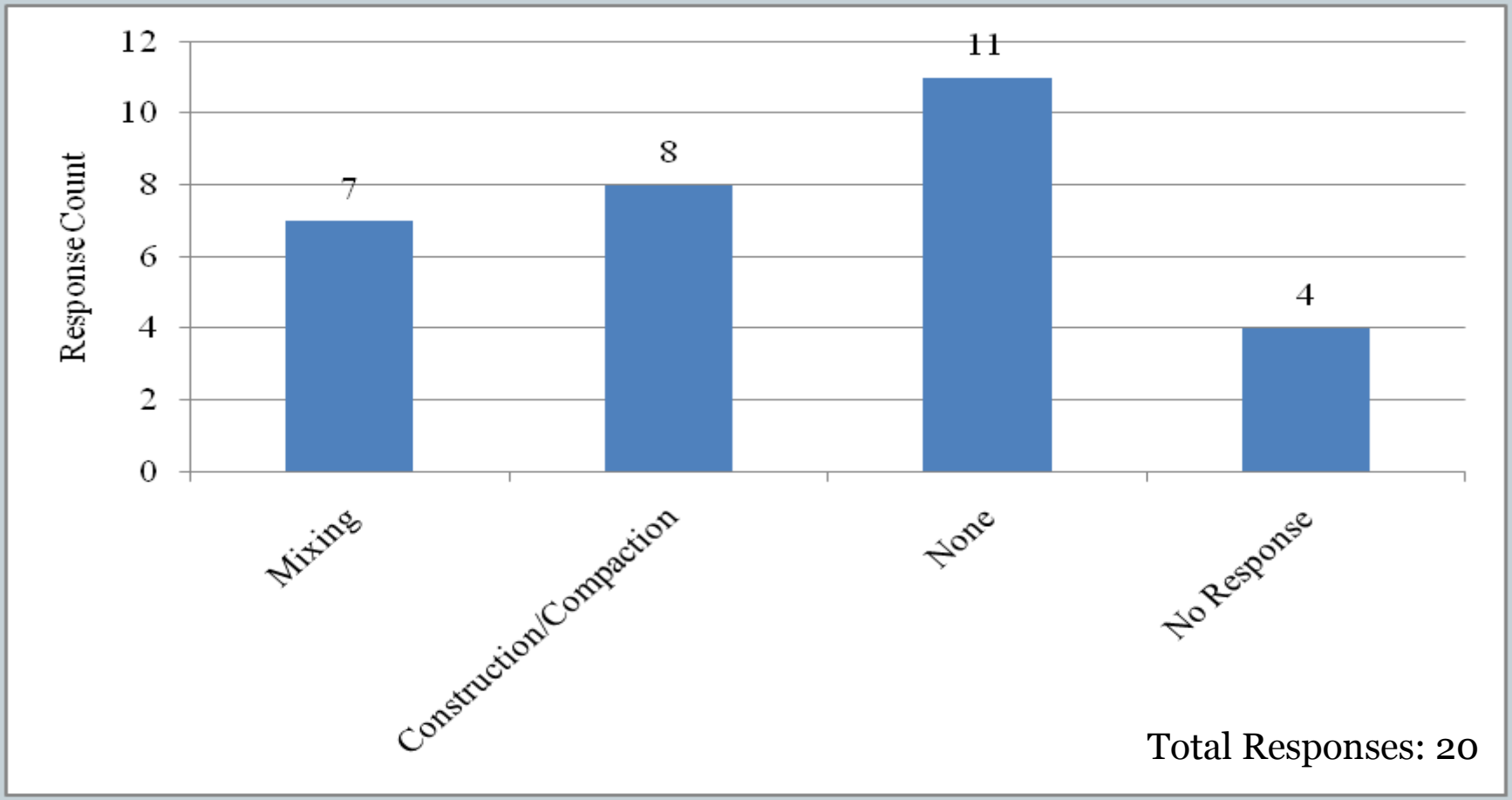
Development method for specification or approval procedure in agencies

Analysis of Responses - Acceptance Plan



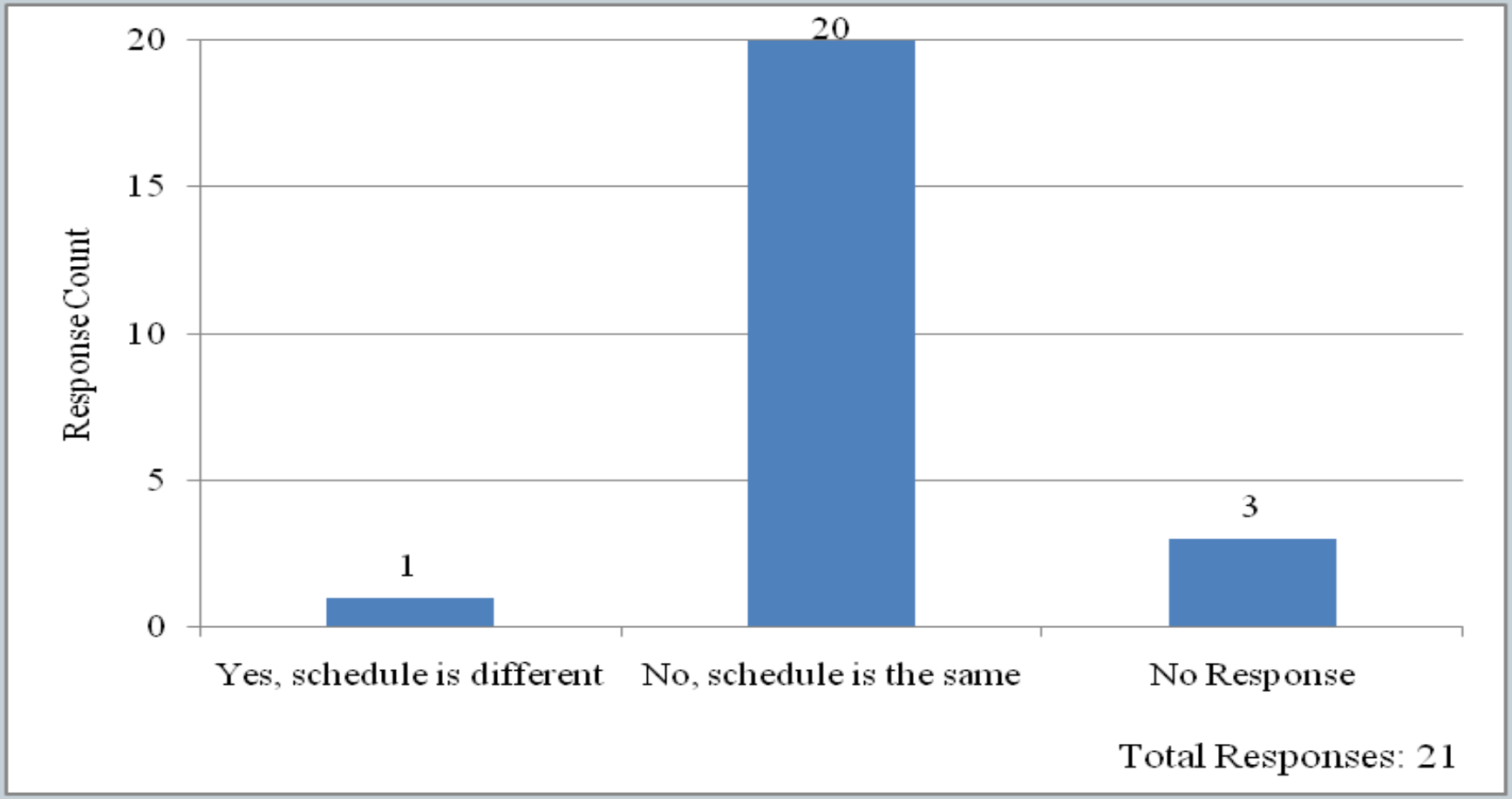
Modifications in WMA acceptance plan components compared to HMA

Analysis of Responses - Acceptance Plan (cont'd)



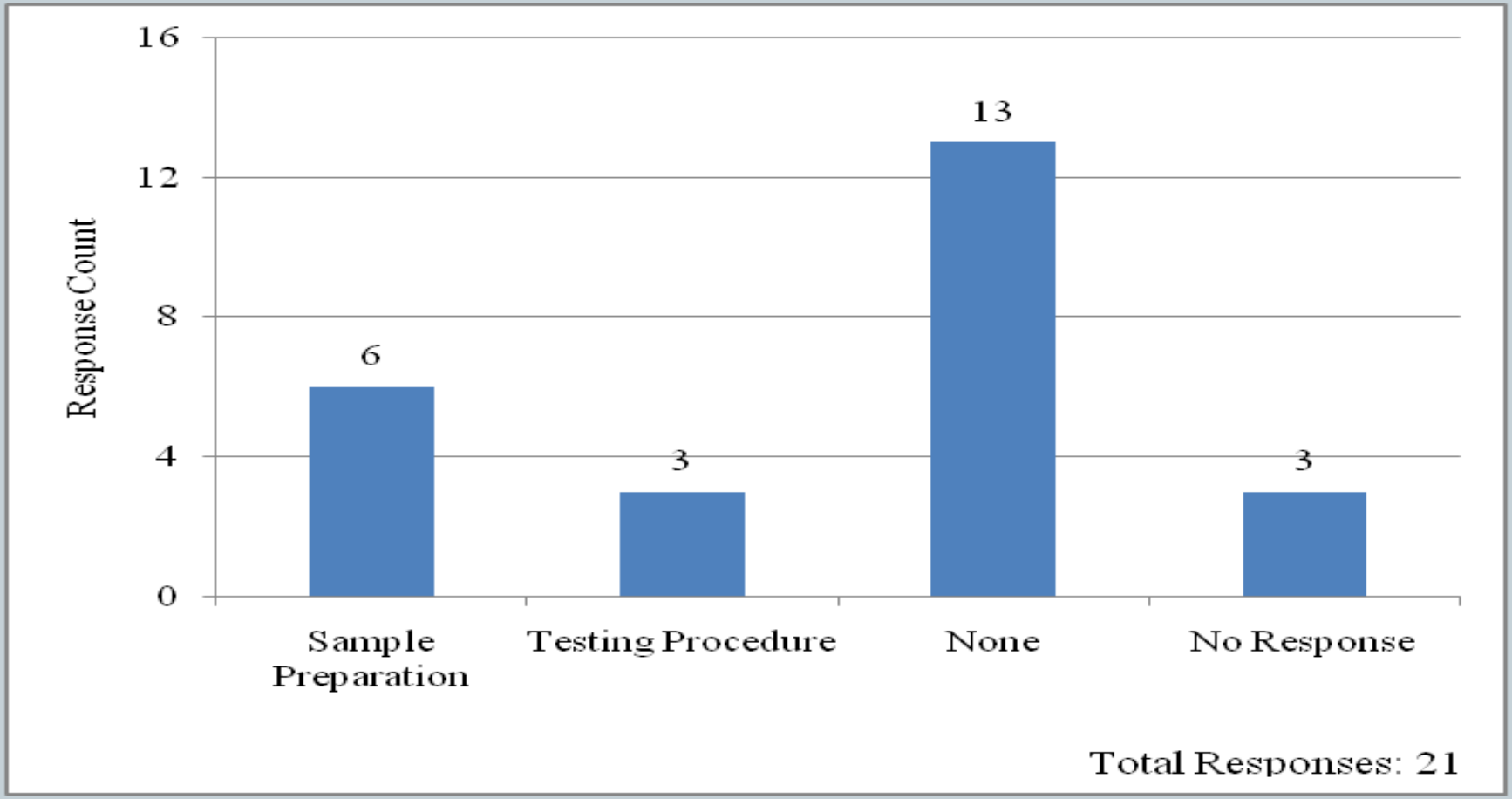
Modifications in temperature monitoring for WMA compared to HMA

Analysis of Responses - Acceptance Plan (cont'd)



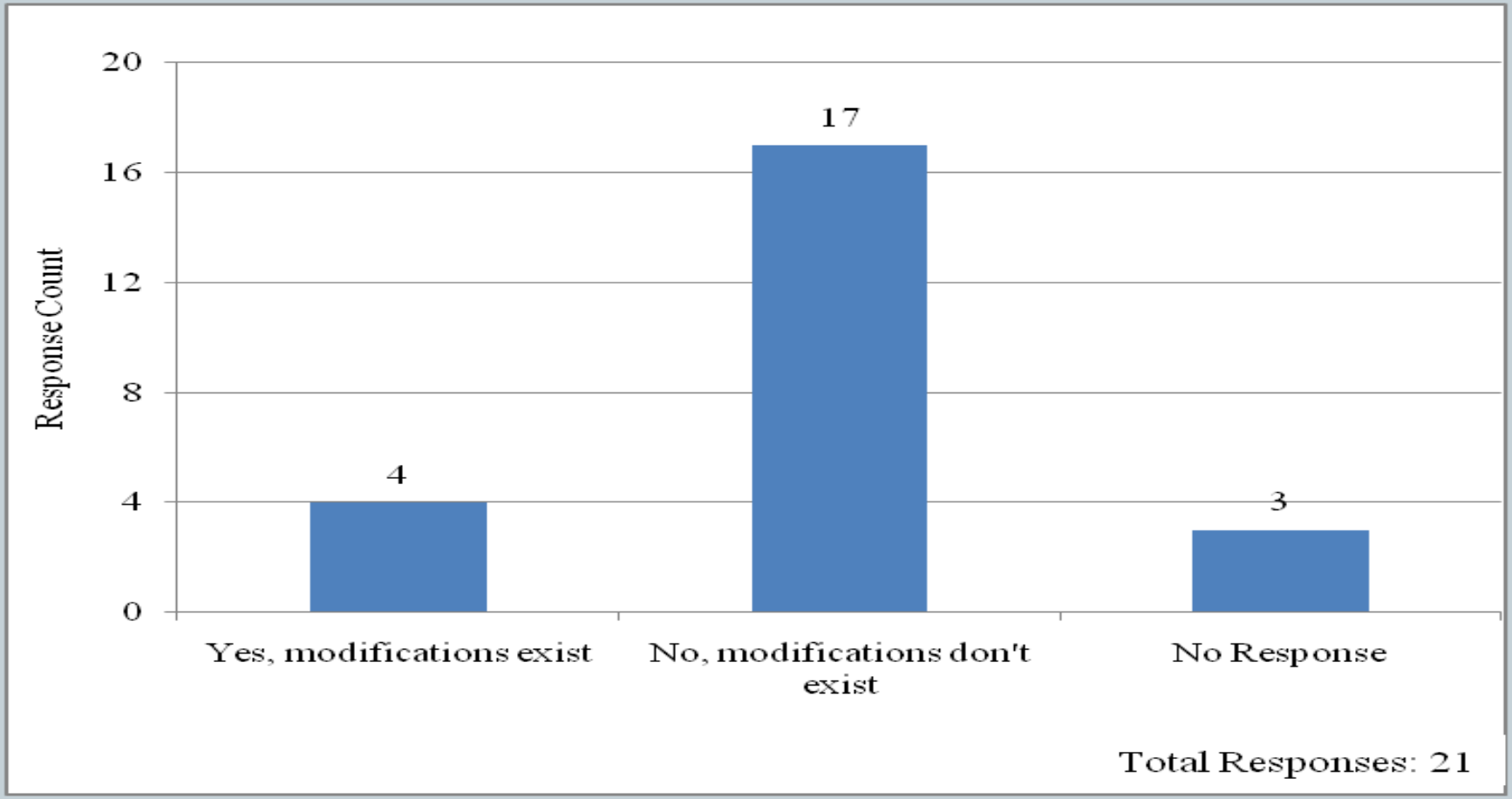
Changes in WMA quality assurance sampling schedule compared to HMA

Analysis of Responses - Acceptance Plan (cont'd)



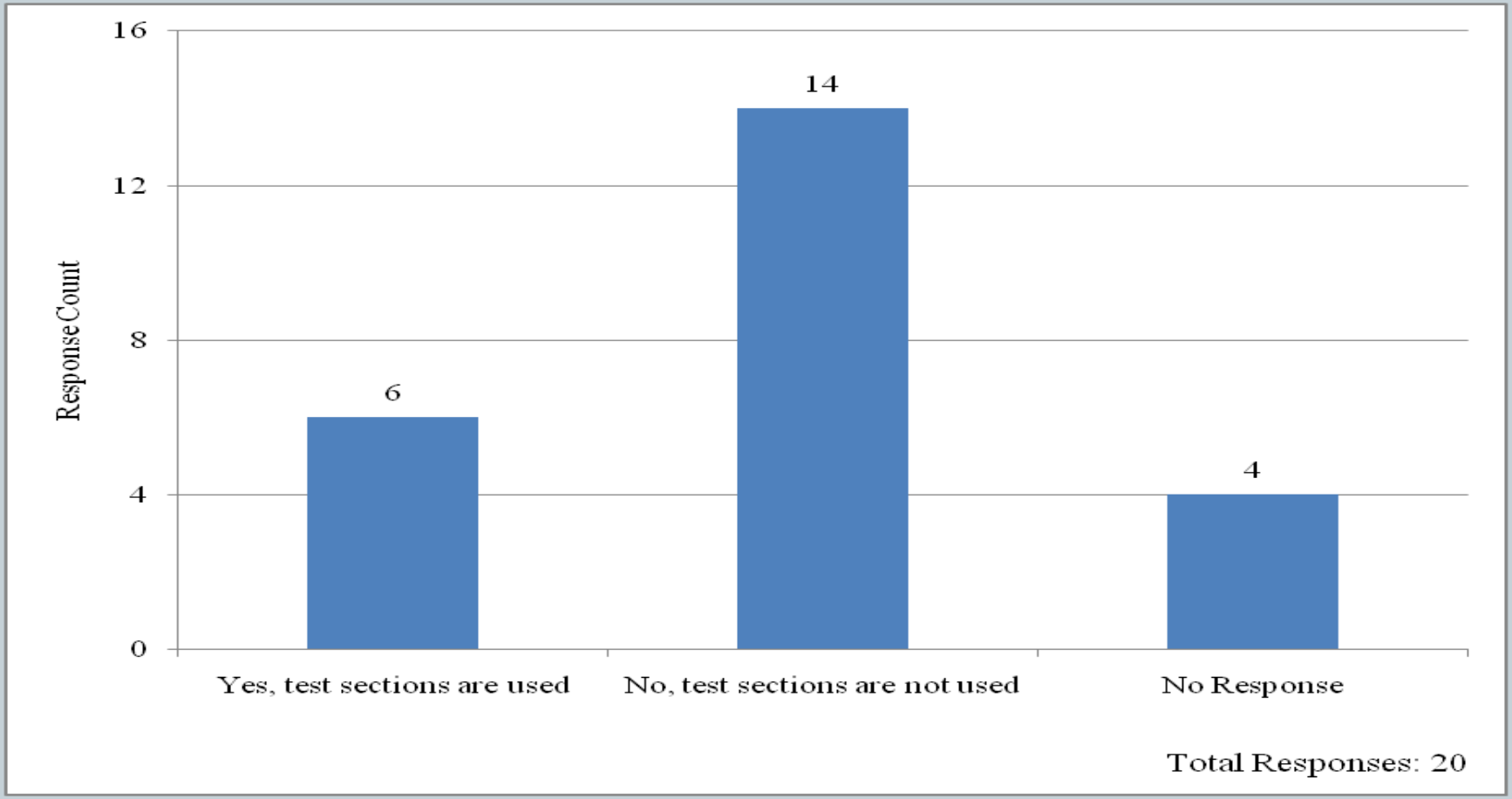
Modifications in lab assurance testing for WMA compared to HMA

Analysis of Responses - Acceptance Plan (cont'd)



Modifications in WMA quality control plan compared to HMA

Analysis of Responses - Acceptance Plan (cont'd)



Use of test section for WMA evaluation

Recommendations

Applicability of HMA Testing on Warm Mix Asphalt

In addition to traditional AASHTO T283 freeze and thaw (F-T) and tensile strength ratio (TSR) the followings are recommended to evaluate asphalt mixtures subjected to F-T moisture conditioning:

- Superpave indirect tension (IDT) tests
- Dynamic modulus test
- Asphalt Pavement Analyzer (APA)
- Hamburg wheel tracking test

Recommendations (cont'd)

Laboratory Evaluation of WMA containing High Percentages of RAP

RAP content will range from 0 to 60%.

Laboratory performance tests include:

- Asphalt pavement analyzer (APA) rutting test
- Hamburg wheel tracking test
- Tensile strength ratio (TSR) test
- Superpave indirect tension (IDT) tests
- Beam fatigue test

Recommendations (cont'd)

Moisture Susceptibility of WMA Technologies

Evaluate the constructability of technologies through monitoring trial pavement sections

Recommended testing includes:

- AASHTO T283 freeze and thaw (F-T)
- Tensile strength ratio (TSR),
- Superpave indirect tension (IDT) tests
- Dynamic modulus test
- Asphalt Pavement Analyzer (APA)
- Hamburg wheel tracking test

Research Collaboration with UND

- NDSU-UND collaboration initiatives
- Supporting research resources
- State, regional and national projects
- HMA/WMA testing facilities: binder and mix testing
- Advanced/chemical testing facilities

Acknowledgement

- NDDOT for supporting the presented research.
- NDDOT Personnel for steering the project and provide guidance/assistance.

Thank You!